SALMON AND STEELHEAD HABITAT LIMITING FACTORS

WATER RESOURCE INVENTORY AREA 16
DOSEWALLIPS-SKOKOMISH BASIN


Hamma Hamma River, Ecology Oblique Photo, 2001

WASHINGTON STATE
CONSERVATION COMMISSION

FINAL REPORT

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ABBREVIATIONS AND ACRONYMS

AIMT	Annual Instantaneous Maximum Temperature
7-DADMT	7-day Average of Daily Maximum Temperature
21-DADT	21-day Average Daily Temperature
BIBI	Benthic Invertebrate Biotic Index
cfs	cubic feet per second
CREP	Conservation Reserve Enhancement Program
Ecology	Washington State Department of Ecology
HCCC	Hood Canal Coordinating Council
HCSEG	Hood Canal Salmon Enhancement Group
JCCD	Jefferson County Conservation District
km	kilometers
LWD	Large Woody Debris
m	meters
MCCD	Mason County Conservation District
Mg/L	Milligrams per Liter
NTU	Nephelometric Turbidity Unit
NWIFC	Northwest Indian Fish Commission
PGST	Port Gamble S'Klallam Tribe
PNPTC	Point No Point Treaty Council
RM	River Mile
SaSI	Salmon and Steelhead Inventory
SASSI	Salmon and Steelhead Stock Inventory
SIT	Skokomish Indian Tribe
SSHEAR	Salmon Screening, Habitat Enhancement and Restoration
SSHIAP	Salmon and Steelhead Habitat Inventory Assessment Project
TAG	Technical Advisory Group
TFW	Timber, Fish and Wildlife
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WCC	Washington Conservation Commission
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WRIA	Water Resource Inventory Area

EXECUTIVE SUMMARY

Water Resource Inventory Area (WRIA) 16 is located within the eastern slope of the Olympic Mountains in Washington State. The WRIA extends from the Turner Creek watershed in southeast Jefferson County southward to, and including, the Skokomish watershed in northwest Mason County. The four principal watersheds, the Dosewallips, the Duckabush, the Hamma Hamma and the Skokomish, originate in the rugged terrain of the Olympic Mountains and terminate along the western shore of Hood Canal. Numerous smaller independent streams are interspersed between the larger river systems. The region has a temperate, marine climate with wet winters and dry summers with precipitation ranging from approximately 60 inches per year along Hood Canal to approximately 120 inches per year near the headwaters of the major rivers (USFS 1999).

Prior to 1855, the Twana people occupied all of WRIA 16, particularly the mouths of salmon streams and along the shoreline of Hood Canal where they could hunt, fish and gather shellfish and wild plants. Salmon were an important component of the Twana culture and certain ceremonies and rituals were followed when fishing in the rivers. Settlers arrived in the late 1800s and took up homesteads in the floodplains for farming or worked in logging communities in the upper watersheds.

The majority of WRIA 16 watersheds provide spawning and rearing habitats for all species of salmon: chinook, chum, coho, steelhead, and searun cutthroat trout. In addition, sockeye and bull trout are found in the Skokomish watershed. Hood Canal summer chum, Puget Sound chinook and bull trout are federally listed as threatened under the Endangered Species Act. Summer chum are documented in many WRIA 16 streams: Dosewallips River, Duckabush River, Hamma Hamma River, Johns Creek, and Lilliwaup Creek. They were recently extirpated from Finch Creek and the Skokomish River system. By state standards, chinook are considered critical in the west Hood Canal Rivers (Dosewallips, Duckabush and Hamma Hamma) and depressed in the Skokomish River. Coho stocks are healthy in the Duckabush, southwest Hood Canal and the Skokomish watersheds but their status is unknown in the Dosewallips and the Hamma Hamma rivers. Pink salmon are healthy in the Hamma Hamma River but depressed in the Dosewallips and Duckabush rivers. Winter steelhead are depressed throughout the WRIA and the status of summer steelhead is unknown.

The salmonid species found in WRIA 16 utilize specialized habitats at different times for different life stages. Individual species stagger their upstream migration and each has a unique rearing strategy. All species require adequate flow and water quality, ample and stable spawning gravels, instream structure in the form of large woody debris and/or large boulders, pools and a functional riparian zone while inhabiting the riverine system. While coho, chinook and steelhead remain in the freshwater for an extended period of time following fry emergence, pink and chum salmon tend to move directly out into the salt water. Estuarine, salt marsh, eelgrass and shallow water nearshore habitats are critical to all species of juvenile salmonids as they enter the marine environment. Pink and chum salmon rely heavily on eelgrass beds for feeding and hiding and shallow water for prey avoidance. Studies also show that high salt marsh and estuarine tidal channels are critical habitats for chinook and coho as well.

Human alterations to salmonid habitat can be expected to have various consequences depending on species and life stage. While natural environmental conditions, such as fire, floods and mass wasting events create a disturbance/rebuilding cycle that tends to nourish the aquatic environment, human alterations to the landscape can impact the environment beyond its natural ability to heal and sustain fish resources. Freshwater rearing salmonids are particularly vulnerable to habitat impacts such as elevated water temperatures and dewatering as a result of riparian removal and water extraction, and lack of instream structure such as pool-forming large woody debris. In the marine environment, shoreline alterations, such as bank armoring, over-water structures, and intertidal fill, can disrupt important sediment input from eroding bluffs, alongshore sediment transport, and continuous eelgrass beds that are critical to migrating juvenile salmonids.

Land use activities associated with transportation, shoreline development, forest practices and agriculture have had negative impacts on salmon habitat in WRIA 16. A major impact to the nearshore environment is SR101, which extends north/south along the entire shoreline. The highway acts as a sea dike across the large estuaries, truncating tidal sloughs and distributary channels and impacting smaller estuaries by reducing and/or eliminating tidal influence and estuary function. The highway also interrupts backshore sediment delivery to the marine environment, thereby reducing longshore sediment transport processes that support and sustain the physical character and biological productivity of the upper intertidal habitats. Impacts to the nearshore are further exacerbated by shoreline development that extends into the intertidal area, resulting in elimination or degradation of intertidal and subtidal habitats that provide a wide range of diverse migration, rearing and refuge opportunities for juvenile salmon. These impacts involve the fragmentation of eelgrass beds, interruption of sediment drift and loss of valuable salt marsh and lagoon habitats. The removal of riparian vegetation weakens bank stability which could threaten home sites and often results in bank armoring/protection as well as the invasion of non-native species. Native riparian vegetation also provides an insect food source for juvenile fish, shaded cover from high temperatures in the upper intertidal zone, and woody debris to beaches to help build complex habitat and stability to beach substrate.

Forest practices have also had negative impacts on salmon habitat in WRIA 16. Habitat conditions in the federally owned lands that occur in many of the upper watersheds, managed by the US Park Service and the US Forest Service, are among the best in the WRIA. The Park Service strives to maintain natural habitats through preservation and their conservation measures protect downstream riverine function. The US Forest Service has improved their land management strategy and has adopted a Riparian Reserve Program which provides for well functioning riparian habitat that ensures conifer canopy cover for temperature control, large woody debris recruitment, natural streambank stability to limit fine sediment input, and migratory corridors for numerous wildlife species. Their management strategy calls for selective thinning to rebuild the health of the watershed rather than clear-cutting remaining forested habitats. This is in contrast to the large clearcuts, numerous roads and often inadequate riparian zones on state-owned and private forest lands. The riparian zone's ability to intercept fine sediments resulting from exposed soils diminishes as the riparian buffers decrease as does large woody debris recruitment. The lower Dosewallips, McDonald, lower Hamma Hamma, lower Lilliwaup, Skokomish mainstem and its tributaries have degraded riparian habitats and consequently poor large woody debris recruitment. In addition to riparian degradation, mass wasting events and the subsequent above-normal delivery of sediments in the Skokomish, lower Duckabush, Schaerer and Johns Creek watersheds have been directly linked to improper forest road construction, maintenance and/or abandonment. Road densities are high in many of the WRIA 16 watersheds, particularly Rocky Brook, lower Hamma Hamma, lower Lilliwaup, many independent streams, and the mainstem Skokomish and its tributaries. The US Forest Service has properly decommissioned many roads in the South Fork Skokomish watershed which decreases road density and reduces the number of potential road failures. Their watershed restoration activities have also included reestablishment of riparian buffers and restoration of instream habitat complexity.

Agriculture activities and residential development within the floodplains of many WRIA 16 watersheds have channelized mainstems and tributaries, drained beaver ponds for livestock grazing, and eliminated forested riparian zones. These activities have degraded valuable juvenile overwintering and rearing habitat associated with beaver ponds, decreased broad channel meanders, eliminated floodplain connectivity to side channel habitats, reduced channel complexity and instream structure, minimized pool/riffle ratios, decreased streambed and streambank stability, and eliminated healthy riparian zones. The Skokomish River is a good example where agriculture activities, such as dike construction, channelization, riparian degradation and large wood removal have contributed to aggradation problems from excessive sediment loads and unstable streambeds and streambanks. The lower Dosewallips, Hamma Hamma, Lilliwaup, and many smaller independent tributaries experience floodplain and estuary degradation from channelization, dike construction, riparian removal and reduced channel complexity.

In order to ensure that salmonid habitats can produce sustainable and harvestable populations into the future, the Technical Advisory Group consistently placed as high priority action recommendations the preservation of properly functioning habitats, particularly estuaries, actively eroding feeder bluffs and riverine riparian corridors. Preservation of critical habitats is a cost effective tool to ensure that properly functioning habitats will remain as such into perpetuity.

When a watershed has been severely impacted and cannot heal itself within a reasonable time frame, habitat restoration may be necessary. Once the source of the problem has been identified, rehabilitation activities can be directed to restore properly function condition. Such activities in the riverine environment might include removal of artificial barriers to fish passage, reestablishment of a healthy riparian zone, restoration of channel sinuosity and/or complexity, installation of cattle exclusion fences, abatement of mass wasting events, and/or removal of streambank armoring. Restoration activities in the nearshore might include removal of intertidal fill, restoration of lagoon and/or salt marsh connectivity, removal of shoreline armoring and/or removal of estuary constrictions that impede natural function. In some cases, property acquisition may be necessary prior to initiating restoration activities. The Technical Advisory Group identified restoration activities for the majority of the watersheds in WRIA 16 as well as along the entire nearshore environment. The Technical Advisory Group also identified assessments and studies needed to fill data gaps. In some cases, assessments might be necessary prior to beginning preservation or restoration activities.

Protection and restoration activities are only a part of the salmonid habitat equation. Land use regulations and their enforcement must be redirected to protect the valuable fish and wildlife resources that WRIA 16 has to offer. Preventing habitat degradation is a very cost effective tool to ensure sustainable populations of fish and wildlife into the future.

The Habitat Limiting Factors Analysis for WRIA 16 summarizes existing salmonid habitat data and represents the most current compilation and review of riverine and nearshore processes and human-induced impacts to salmon productivity. It does not cover salmonid productivity limited by hydroelectric dams, harvest or hatcheries. Data included or referenced in this report include watershed analysis, formal habitat inventories or studies specifically directed at evaluating fish habitat, salmon stock inventories and assessments, comparison of historic and contemporary mapping and photography, and other watershed data not specifically associated with fish habitat evaluation. Where data are lacking, the Technical Advisory Group (TAG) relied on its combined professional knowledge to assess the extent to which habitat conditions are affecting salmonid productivity. Where data and best professional knowledge are lacking, the habitat elements have been identified as data gaps and warrant additional specific watershed research or evaluation.

The following report is a detailed assessment of habitat limiting factors in WRIA 16. Each watershed assessment is complete with a list of action recommendations for that watershed. The nearshore discussion is followed by a prioritized list of nearshore projects for the entire WRIA. This report provides information that can be used in the development of salmonid habitat protection and restoration strategies. It is a snapshot in time that can be supplemented with additional data from habitat assessments and habitat restoration successes as information becomes available.

INTRODUCTION

Salmonid Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;
- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon;"
- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. In waters shared by salmon, steelhead trout and bull trout we will include all three. Later, we will add bull trout only waters as well as cutthroat trout.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydropower, and harvest limiting factors are being dealt with in other forums.

THE RELATIVE ROLE OF HABITAT IN HEALTHY POPULATIONS OF NATURAL SPAWNING SALMON

(Chapter Author – Carol Smith, PHD)

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can results in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bull trout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population's characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct juvenile life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, and upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al.. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but has been observed as early as late July and as late as mid-January (WDF et al.. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al.. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from 1-3 years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, and weed control.

Steelhead have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al. 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al.. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

Dolly/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they stay during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bull trout are generally recognized as a sensitive species by natural resource management agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last

10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples.
Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

This report provides information that can and should be used in the development of salmonid habitat protection and restoration strategies. It should be considered a living document, with additional habitat assessment data and habitat restoration successes incorporated as information becomes available.

WATERSHED CHARACTERIZATION

Location: WRIA 16 lies within the eastern slope of the Olympic Mountains along the western shore of Hood Canal. The four principal watersheds, the Dosewallips, the Duckabush, the Hamma Hamma and the Skokomish, originate in the rugged terrain of the Olympic National Park or Olympic National Forest. Numerous smaller independent streams are interspersed between the larger river systems and drain the lower foothills. There are 557 identified streams contributing over 825 linear miles of rivers, tributaries and independent streams within WRIA 16 (Williams et al. 1975).

Geology: During the Eocene Epoch, approximately 37 to 50 million years ago, the land underlying WRIA 16 was the floor of the Pacific Ocean (PSCRBT 1995). Tectonic plate movement, uplifting, erosion and glacial activity worked over millions of years to shape the landscape observed today. The combination of geology, glaciation, and natural weathering processes has created a topography ranging from alluvial and glacial valley bottoms and relatively gentle slopes in the eastern part of the watershed to the rugged and steep terrain associated with near vertical slopes and dissected incised valley side slopes in the headwaters (USFS 1999). Bedrock exposures/outcrops are common and are of a deep marine origin that includes both sedimentary and volcanic rocks. A number of bedrock faults and folds are results of plate tectonic movements. Glacial deposits are thin, particularly in the southern part of the WRIA, and commonly experience landslides and erosion (PSCRBT 1995).

Climate: The present climate of the Olympic Peninsula is relatively warm and wet compared to the past 50,000 years. It is described as a temperate, marine climate with wet winters and dry summers. It supports a diverse flora and favors the growth of trees. The climate for the past 1,000 years has not been constant. Between the 1300s and 1850s, the Little Ice Age brought cold winters and generally a wet, unfavorable climate in the northern latitudes, resulting in poor growing conditions for many tree species. However, these conditions were favorable to Pacific silver fir, which expanded its range at that time but is now reducing its range (Henderson 1983 cited in USFS 1999).

The northeastern portion of WRIA 16 is in the rainshadow of the Olympic Mountains and is therefore drier than the remaining watershed to the south. It is also drier at sea level. Precipitation ranges from approximately 60 inches per year along Hood Canal to approximately 120 inches per year near the headwaters of the major rivers (USFS 1999).

Disturbance Regime:
The vegetation reflects various environmental and climatic factors. Patterns of vegetation are the result of disturbance. Disturbances are events that result in radical change, often in a very short time period. The primary disturbances in WRIA 16 include fire, windthrow, insects and disease, mass wasting, harvest, non-native invasive plant species (USFS 1999) as well as flooding.

The Olympic National Park manages fire within a "fire use zone" for resource benefits. Naturally occurring fires are monitored but not artificially extinguished. The Olympic National Forest, on the other hand, extinguishes all fires as soon as possible (USFS 1999).

Native American Cultural Background: Prior to 1855, the Twana people occupied the entire Hood Canal drainage, particularly the mouths of salmon streams or near the canal shore. The Twana were not a "tribe" or "band" in the sense of today's tribes, but were a speech community composed of several villages which spoke Twana as their primary language and shared common customs and a common territory. These villages were occupied year round and each contained several large houses, smaller structures and often a potlatch house. The Twana were primarily of the saltwater culture type, gathering much of their food from the shoreline or marine waters. During the summer, however, small groups of the community dispersed over a wide territory to hunt, fish and gather shellfish and wild plants. During this semi-migratory existence they lived in small, pole-framed, mat-covered structures or lean-to shelters. Permanent villages were located at Dabop (Dabob), Quilcene, Dosewallips, Duckabush, Hoodsport, Skokomish, and Vance Creek in WRIA 16, and Tahuya and Duhlelap along the southeast shores of Hood Canal. All were of the saltwater culture type with the exception of Vance Creek, where they were considered the inland culture type. The Skokomish village extended their range into the upper South Fork and Lake Cushman areas for hunting and plant gathering, but were still considered the saltwater culture type (Elmendorf and Kroeber 1992).

Salmon were an important component of Twana culture and certain rituals had to be followed while fishing in the river. The river had to be kept clean before salmon started running. No rubbish or food scraps could be thrown into the river, nor could canoes be baled out in the river. Each season the tribe celebrated the catch of the first salmon. The salmon was specially cared for prior to cooking and all members of the community ate from this salmon. The bones were then returned to the river following certain rituals. Salmon was dried or smoked and stored for the winter, during which it was the main staple (USFS 1995).

The Skokomish, whose name became that of the reservation following the Point No Point Treaty in 1855, were one of the Twana villages. The Skokomish Tribe's "usual and accustomed areas" for hunting, fishing and shellfish gathering include many areas in Hood Canal and Puget Sound (PSCRBT 1995). Today, there is a Skokomish Tribal Council and the tribe has established its own court to enforce ordinances and to regulate hunting and fishing.

Post Settlement: Small temporary settlements were established in the 18th and early 19th centuries by explorers. Settlers arrived in the late 1800s and took up homesteads (160 acres) in anticipation of making a livelihood at farming. As such, these homesteads were likely located in the lowlands and were located throughout WRIA 16 (USFS 1995). Logging communities were established in the upper watersheds at approximately the same time with a number of log flumes along the shoreline that were an early efficient means to transport cut logs from the uplands to the salt water (Steve Todd, personal communication, 2003). The Cushman dam and powerplant were constructed in the 1920s.

Demographics: There are no incorporated cities in WRIA 16. The two largest population centers, Brinnon to the north and Hoodsport to the south, are situated on SR101 and maintain a rural character. Smaller communities include Eldon, Lilliwaup and Potlatch. The majority of the residential development in WRIA 16 is along the shoreline of western Hood Canal. Approximately 25% of the population is over the age of 60, 50% between 18 and 60 and 25% under 18. The shoreline is a popular place for retirement due to the mild climate and access to numerous recreation opportunities (PSCRBT 1995).

Land Use: Managed forestland, both public and private, is the primary land use, encompassing approximately 75% of the geographic area. Other uses, parks and designated wilderness (18%), residential (3%), utilities, transportation corridors and retail (4%) are small by comparison (PSCRBT 1995).

DISTRIBUTION AND CONDITION OF STOCKS

Each species of salmon has a unique life history pattern, which allows each to partition the habitat in rivers where the species coexist. In addition to this diversity of life histories between species, there is a rich diversity of life histories within a species or stock, a strategy that contributes to sustainability through changing environmental conditions (Lichatowich 1993a). WRIA 16 is home to six native anadromous species (chinook, chum, coho, pinks, steelhead and searun cutthroat) and three fluvial/adfluvial species (bull trout, rainbow trout and cutthroat trout.

Stocks were evaluated as to status by the state and tribes in the 1992 Salmon and Steelhead Stock Inventory (SASSI). Washington Department of Fish and Wildlife has updated the report in the 2003 Salmon and Steelhead Inventory (SaSI).

Chinook *(Oncorhynchus tshawytscha)*

Chinook salmon spawning grounds begin just above tidal influence and can extend up to 1,200 miles upriver, as in Alaska. They prefer deeper water and larger gravels for spawning that the other salmonids. There appear to be two general patterns: the stream type and the ocean type. The stream type chinook remain in fresh water for an entire year prior to migrating to the salt water the following spring. The ocean type tends to remain in freshwater for a shorter duration, heading to the sea within a few months of emergence from the redd. Smolts of both varieties spend some time close to shore prior to moving to the open ocean (Lichatowich 1993a). They tend to mature at four or five years, but that can vary from two to nine years. There are typically three run timings when adults return to the freshwater to spawn: spring, summer and fall. The fry emerge from the gravels the following spring. Chinook prefer water temperatures of 12 to 14 degrees C (Lichatowich 1993a).

Chinook salmon in Hood Canal were previously managed as a single stock of mixed origin with composite production (WDFW and WWTTribes 1994). Individual stocks have recently been identified based on geographic separation and spawning timing (WDFW, DRAFT IN REVIEW, 2003). The summer/fall variety are found in WRIA 16 and typically spawn mid-September to late October. They are listed with Puget Sound chinook as threatened under the Endangered Species Act. A spring variety was historically found in the upper South Fork Skokomish as well as the North Fork Skokomish, but they are not included in the listing, possibly because they are assumed to be extirpated. Local residents observe large bodied salmonids in the south fork canyon during June and July. Skokomish tribal staff snorkeled the mouth of the North Fork in mid July 2002, and observed several chinook, which were beginning to assume spawning coloration. The few chinook in the river at that time were confined to the lower river (Marty Ereth, personal communication, 2002).

Chinook salmon, also known as king salmon, are found in all the major rivers in WRIA 16 where spawning conditions are suitable. In addition, estuarine and nearshore habitats are critical habitats for juvenile chinook as migration corridors and feeding and refuge. Chinook smolts have been observed utilizing smaller independent systems and their estuaries, such as Fulton Creek and its lower tributary (Hirschi and Doty, unpublished data, 2002).

Mid-Hood Canal Chinook

The Mid-Hood Canal chinook stock is comprised of chinook, which spawns in the Hamma Hamma, Duckabush and Dosewallips watersheds. Mid-Hood Canal chinook were identified as a stock in 2002 based on their distinct spawning distribution, genetic, morphological and timing similarity, and the proximity of the natal streams. This is likely a mixed stock with composite production. It is assumed that many of the naturally spawning chinook were strays from local hatcheries and/or were adults returning from hatchery fry released into the Hamma Hamma, Dosewallips, and Duckabush rivers (WDFW, draft in review, 2003). The critical escapement threshold is 400 chinook for the Mid-Hood Canal management unit (PSIT and WDFW 2001). The mean escapement of 244 chinook for the Mid-Hood Canal stock from 1990 through 2001 has been lower than the critical escapement threshold and no productivity data are available, so the stock status is rated **critical** (WDFW, draft in review, 2003).

Below is information on the sub-populations of chinook in the Dosewallips, Duckabush and Hamma Hamma watersheds, which comprise the Mid-Hood Canal chinook stock.

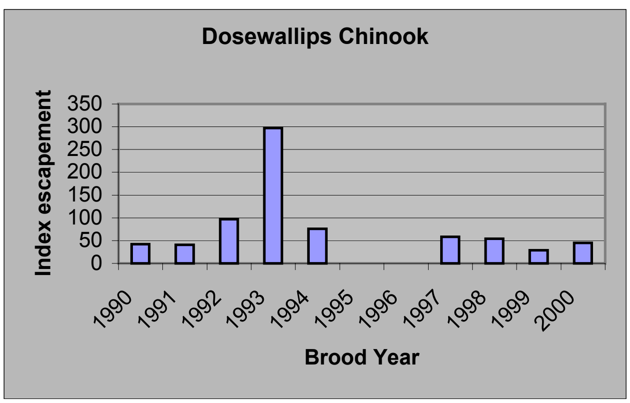

Figure 1. Dosewallips Chinook Escapement, 1990 to 2001. Data provided by Thom Johnson, WDFW

Dosewallips Chinook

Most spawning takes place in the lower twelve miles of the Dosewallips River between September and October. Escapement estimates are based on redd counts and/or live spawner counts from river mile 0.0 to 2.3 or river mile 0.0 to 6.7 on the mainstem, depending on weather and flow conditions. Upper reaches have also been surveyed in the Dosewallips River since 1998, but few chinook adults or redds have been observed (WDFW, draft in review, 2003).

In 1992 Dosewallips chinook were considered part of the Hood Canal summer/fall chinook stock and were not rated as a separate stock under the Salmon and Steelhead Stock Inventory (SASSI).

Duckabush Chinook

Chinook currently spawn in the lower two to three miles of the Duckabush River during September and October. Potential spawning habitat is present upstream of river mile 3.0 but has not been surveyed regularly (WDFW, draft in review, 2003).

Escapement estimates are based on redd counts and/or live spawner counts from river mile 0.0 to 2.3. Upper reaches have been surveyed since 1998 but few chinook adults or redds have been observed (WDFW, DRAFT IN REVIEW, 2003).

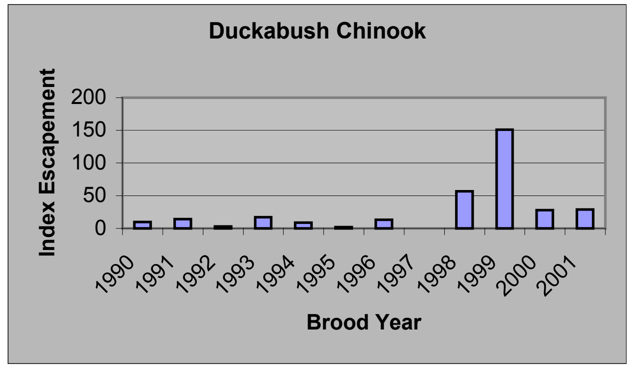

Figure 2. Duckabush Chinook Escapement, 1990 to 2001. Data provided by Thom Johnson, WDFW.

In 1992 Duckabush chinook were considered part of the Hood Canal summer/fall chinook stock and were not rated as a separate stock in SASSI. From 1995 through 1999, Hood Canal Salmon Enhancement Group and Long Live the Kings, as part of their Wild Salmon Conservancy project and with technical guidance from WDFW and Tribal staff, released unfed fry into Johnson Creek, a right bank tributary to the Duckabush at approximately river mile 6.0. Between 1991 and 1995, 100,000 unfed fry were released on an annual basis at the same site as a WDFW/ALEA COOP project.

Hamma Hamma Chinook

Chinook spawn in the lower two miles of the Hamma Hamma River and occasionally in the lower reaches of John Creek, a right bank tributary at approximately river mile 1.4, in September and October (WDFW, draft in review, 2003). Genetic sampling to date suggests that there is little genetic differentiation between Hamma Hamma natural spawners and those in neighboring Hood Canal systems (Marshall 2000 cited in WDFW, draft in review, 2003).

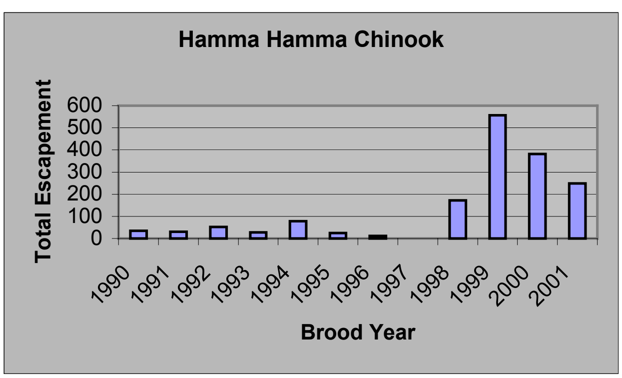

Figure 3. Hamma Hamma Chinook Escapement, 1990 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates based on redd counts and/;or live spawner counts from river mile 0.3 to 1.8 in the Hamma Hamma River and in lower John Creek (WDFW, draft in review, 2003).

In 1992, Hamma Hamma chinook were considered part of the Hood Canal summer/fall chinook stock and were not rated as a separate stock in SASSI.

Hamma Hamma chinook are likely a mixed stock with composite production, based on the otolith records which indicate that many of the naturally spawning chinook are products of a local stock restoration program. In 1995, Hood Canal Salmon Enhancement Group and Long Live the Kings, with technical support from WDFW and Tribes, began a Wild Salmon Conservancy project on John Creek with the goal of restoring a naturally sustainable chinook population in the Hamma Hamma. Chinook released as fed fry from the program began to return as adults and contribute to natural escapement in 1998 (WDFW, 2003). Beginning in 2000, chinook adults returning to the Hamma Hamma were included in the program as broodstock (WDFW, draft in review, 2003). Prior to the conservancy program, unfed fry were released into John's Creek as part of the WDFW/ALEA COOP program. Both projects used George Adams Hatchery and/or Hoodsport Hatchery stock as their egg source.

Skokomish Chinook

Skokomish chinook were identified as a stock in 2002 based on their geographic separation. Spawning takes place in the mainstem Skokomish, in the lower portions of the North and South Forks and in Purdy, Vance and Hunter Creeks. Hatchery spawning takes place at George Adams Hatchery. Spawning generally occurs from mid-September through October with peak spawning in mid-October.

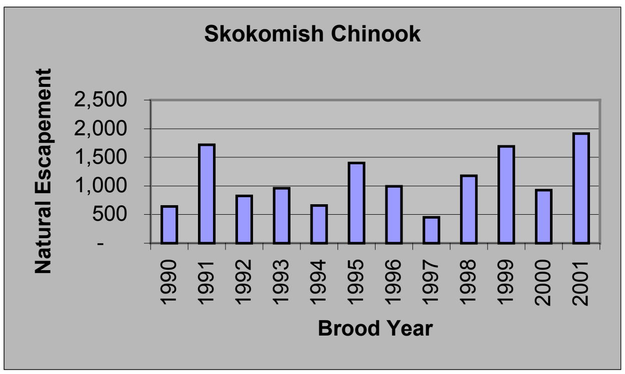

Figure 4. Skokomish River Chinook Escapement, 1990 to 2001. Data provided by Thom Johnson, WDFW.

Estimates of naturally spawning chinook are based on counts of live spawners and/or redds in the mainstem Skokomish from river mile 2.2 to 12.7, in Purdy Creek from river mile 0.0 to the George Adams hatchery, and in the South Fork Skokomish river mile 0.0 to 5.5. Hatchery escapements are based on counts at the George Adams Hatchery on Purdy Creek, a right bank tributary to the Skokomish at river mile 4.1 (WDFW, draft in review, 2003; Williams et al. 1975).

In 1992, this stock was part of the Hood Canal summer/fall chinook stock and did not receive a separate status rating under SASSI. In the proposed 2002 SaSI, the stock is rated **depressed** because of chronically low natural escapements. The total escapement goal for the stock is 3,650 adult spawners (1,650 natural spawners and 2,000 returning to George Adams Hatchery). The total goal for the stock has been met because hatchery escapements have exceeded the hatchery goal in most years. The goal for natural spawners, however, has been met only three times since 1990 (WDFW, draft in review, 2003).

Genetic analysis suggests that there is not significant genetic differentiation between Skokomish natural chinook spawners and George Adams Hatchery/Hoodsport Hatchery chinook (WDFW, draft in review, 2003).

Chum (*Oncorhynchus keta*)

Chum salmon, also known as dog salmon and/or calico salmon, utilize the low gradient (0-8%) reaches of the stream for spawning, and typically spend less than 30 days in the freshwater after emergence in spring. They remain in the estuary and nearshore environments, feeding primarily on copepods, tunicates and euphausiids, prior to migrating out to the ocean (Lichatowich, 1993a). Chum return to freshwater in three to five years to spawn and tend to be group spawners with each female accompanied by one or more males.

The abundance of chum salmon in Puget Sound tends to fluctuate naturally during even/odd cycles, suggesting a possible competitive interaction with pink salmon in estuary or nearshore habitats (Salo 1991 in McHenry and Lichatowich 1996). Their carcasses provide high nutrient values for juvenile salmonids and numerous wildlife species. There are three distinct run times: summer, fall late fall. All three are found in WRIA 16.

Summer Chum

Summer chum, federally listed as threatened under the Endangered Species Act, are found in several WRIA 16 watersheds. They begin their upstream migration between mid to late August through mid-October with fry emergence toward the end of March through the end of April, depending on water temperatures. They are of native stock origin and managed for wild production (WDFW and WWTTribes 1994; WDFW and PNPT Tribes 2000; WDFW, draft in review, 2003).

While low summer flows and habitat degradation in some of the systems have contributed to the decline of summer chum, an additional factor in the decline could also result from the marginalization of the stock through designation as a secondary management unit in the Hood Canal Salmon Management Plan (Lichatowich 1993a). The early chum populations in all streams entering Hood Canal were combined into one stock, with the exception of the Union River (Lichatowich 1993a). Examination of the standard of substantial reproductive isolation, indicated by distributional and genetic differences, nine distinct summer chum stocks have been identified: three in the Strait of Juan de Fuca streams and six in Hood Canal streams. An additional seven streams in Hood Canal have been identified as once having summer chum that have been extirpated (WDFW and PNPT Tribes 2000).

Dosewallips Summer Chum

Dosewallips summer chum were recognized as a stock in the state-tribal summer chum conservation initiative based on their distinct spawning distribution and early spawning timing (WDFW and PNPT Tribes 2000) as well as genetic analysis (Phelps et al. 1995 in WDFW, draft in review, 2003). Most spawning takes place in the lower 2.3 miles of the Dosewallips River from mid-September through mid-October. This is a native stock with wild production (WDFW, draft in review, 2003).

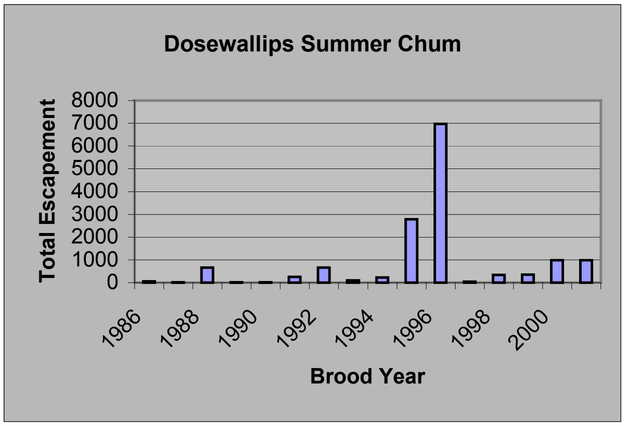

Figure 5. Dosewallips Summer Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Data are total escapement estimates based on live spawner counts from river mile 0.0 to 2.3 on the mainstem Dosewallips. In 1992 this stock was a component of the Hood Canal summer chum stock and did not receive a status rating in SASSI. The stock is rated **depressed** in the proposed 2002 SaSI because of its chronically low escapements. Dosewallips summer chum declined along with other Hood Canal summer chum stocks in the 1980s but have demonstrated improvement in recent years (WDFW, draft in review, 2003). There have been no supplementation efforts on the Dosewallips.

Duckabush Summer Chum

Duckabush summer chum were recognized as a stock in the state-tribal summer chum conservation initiative (WDFW and PNPT Tribes 2000) based on their geographic separation and temporal differences (WDFW, DRAFT IN REVIEW, 2003). Most spawning occurs in the lower 2.3 miles of the mainstem Duckabush from mid-September through mid-October. This is a native stock managed for wild production. There have been no supplementation efforts on the Duckabush. Genetic analysis has shown that Duckabush summer chum are genetically distinct from all other Washington chum stocks examined except Hamma Hamma summer chum (Phelps et al. 1995 cited in WDFW, draft in review, 2003).

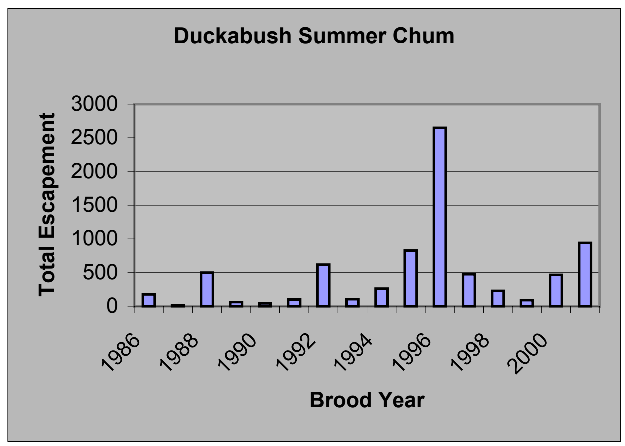

Figure 6. Duckabush Summer Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on live spawner counts from river mile 0.0 to 2.3. In 1992 this stock was a component of the Hood Canal summer chum stock and did not receive a separate status rating in SASSI. The stock is rated **depressed** in the proposed 2002 SaSI because of its continuing pattern of chronically low escapements. Duckabush summer chum declined in the 1980s along with other Hood Canal summer chum stocks. They have shown modest improvement in recent years (WDFW, draft in review, 2003).

Hamma Hamma Summer Chum

Hamma Hamma summer chum were recognized as a stock in the state-tribal summer chum conservation initiative (WDFW and PNPT Tribes 2000) based on their distinct spawning distribution and timing. Allozyme analysis has indicated that Hamma Hamma summer chum are genetically distinct from all other Washington chum stocks examined with the exception of the Duckabush River and Union River (Phelps et al. 1995, cited in WDFW, draft in review, 2003).

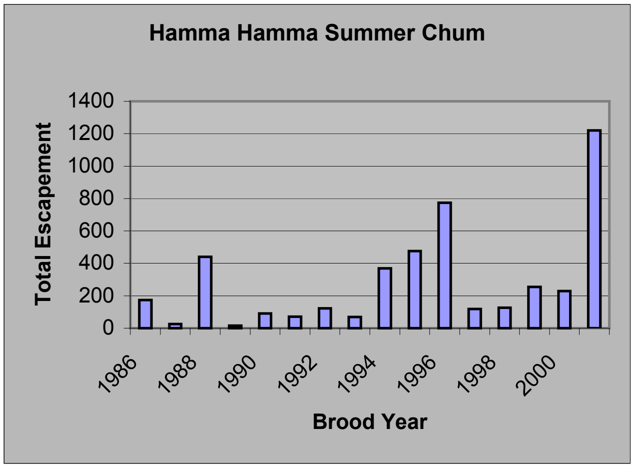

Figure 7. Hamma Hamma Summer Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on live spawner counts from river mile 0.3 to 1.8 in the Hamma Hamma. John Creek, a right bank tributary at river mile 1.4, is also surveyed.

Hamma Hamma summer chum declined along with other Hood Canal summer chum stocks in the 1980s and have shown only slight improvement in recent years. In 1992 this stock was considered a component of the Hood Canal summer chum stock and did not receive a separate status rating. In 2002, the status is rated **depressed** due to continuous low escapements.

The stock is native with composite production. Hood Canal Salmon Enhancement Group and Long Live the Kings, in cooperation with WDFW and the Tribes, initiated a hatchery supplementation program using Hamma Hamma summer chum as broodstock in 1997. Eggs are incubated in remote site incubators, reared until one gram in size, and released into John Creek. Adults produced in the program began to return in 2000 and contribute to the overall production of summer chum in the Hamma Hamma watershed.

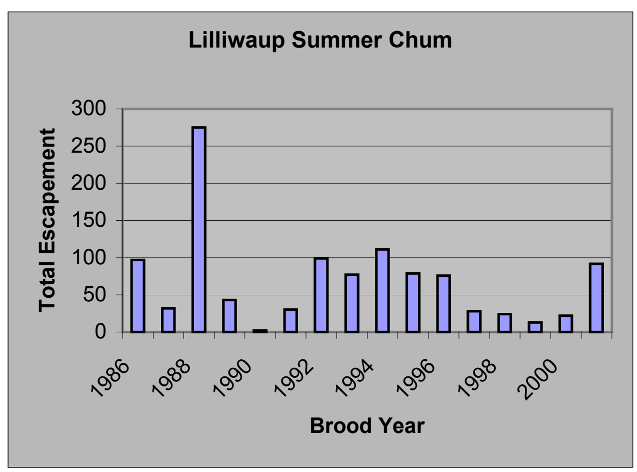

Figure 8. Lilliwaup Summer Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Lilliwaup Summer Chum

Lilliwaup summer chum were recognized as a stock in the state-tribal summer chum conservation initiative (WDFW and PNPT Tribes 2000) based on their geographic separation and temporal differences. Most spawning takes place in the lower mile of the stream from mid-September through mid-October. Stock identification is supported by genetic analysis. Allozyme analysis has shown that Lilliwaup summer chum are genetically distinct from all other Washington chum stocks examined (Phelps et al. 1995 in WDFW, DRAFT IN REVIEW, 2003).

Data are total escapement estimates based on live spawner counts from river mile 0.0 to 0.7 or counts of adults at a temporary trapping facility. Lilliwaup summer chum declined along with other Hood Canal summer chum stocks in the 1980s and have remained at a low level. In 1992, this stock was a component of the Hood Canal summer chum stock and did not receive a separate status rating. In 2002, the stock was rated **critical** because of continuously low escapements.

This is a native stock with composite production. In 1992, Long Live the Kings, in cooperation with WDFW and Tribes, initiated a supplementation program using Lilliwaup summer chum as broodstock to increase the natural production. Summer chum adults from this program began returning in 1995 and have likely contributed to the production of this stock.

Finch Creek Summer Chum

Finch Creek summer chum were recognized as a stock in the summer chum conservation initiative (WDFW and PNPT Tribes 2000) based on their geographic separation and temporal difference. They were present in Finch Creek when the WDFW Hoodsport Hatchery was constructed in 1953. Prior to the hatchery construction, spawning occurred in lower Finch Creek mainly between mid-September and mid-October. The numbers of summer chum counted at the hatchery rack declined through time, in spite of stock restoration efforts, and the last summer chum were observed in 1976.

In 1992 this stock was a component of the Hood Canal summer chum stock and did not receive a separate status rating. In 2002, the stock was rated **extinct** (WDFW, draft in review, 2003).

Skokomish Summer Chum

Skokomish summer chum were recognized as a stock in the summer chum conservation initiative (WDFW and PNPT Tribes 2000) based on their distinct spawning distribution and early spawning timing. Spawning occurred in the lower Skokomish mainstem, Vance Creek, Purdy Creek and the lower North Fork Skokomish River between mid-September and mid-October. Based on the these observations, potential distribution was likely in other spring fed valley tributaries such as Weaver and Hunter creeks and Richert Springs (Marty Ereth, personal communication, 2003).

In 1992 this stock was considered a component of the Hood Canal summer chum stock and was not rated separately. Summer chum were once abundant in the Skokomish River system but declined steadily through the last three decades. Spawning ground surveys report an occasional summer chum but the numbers are not sufficient to represent a self-sustaining stock. In 2002, the stock was rated **extinct** (WDFW, draft in review, 2003).

Fall Chum/Late Fall Chum

Fall chum fisheries are managed to harvest hatchery stock throughout Hood Canal. SaSI designates two stocks of fall chum and four stocks of late fall chum within WRIA 16. Spawning for fall chum generally occurs in November and December with fry emergence in early spring. Spawning for late fall chum generally occurs in December and January with fry emergence in mid- to late spring. Late returns have probably allowed the stock to remain viable since commercial fisheries target earlier returning Hood Canal hatchery-origin fall chum (WDFW, draft in review, 2003).

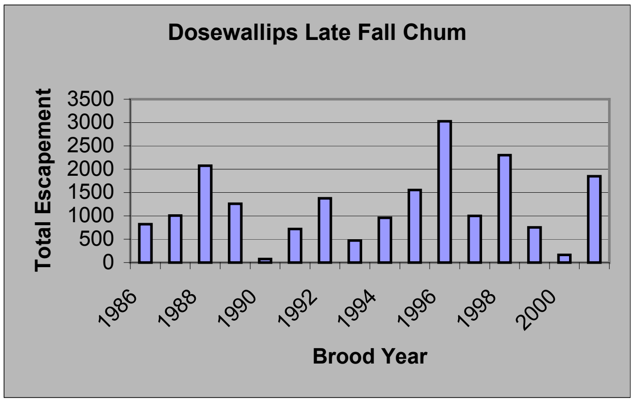

Figure 9. Dosewallips Late Fall Chum Total Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Dosewallips Late Fall Chum

Dosewallips late fall chum were identified as a stock based on their geographic separation and somewhat late return and spawn time. Most spawning occurs in the lower mile of the river from late November through early January.

Data are escapement estimates based on live spawner counts in index areas on the lower Dosewallips River. Escapements have displayed a general and moderate increase since the mid-1980s. SASSI rated the stock healthy in 1992. SaSI rates the stock **healthy** in 2002 as well (WDFW, draft in review, 2003).

Duckabush Late Fall Chum

Duckabush late fall chum were identified as a stock based on their distinct spawning distribution and somewhat late return and spawn timing. Adults generally spawn in the lower mile of the Duckabush and in Fulton Creek, an independent tributary south of the Duckabush, and Pierce Creek, immediately to the north of the mouth of the Duckabush, from late November

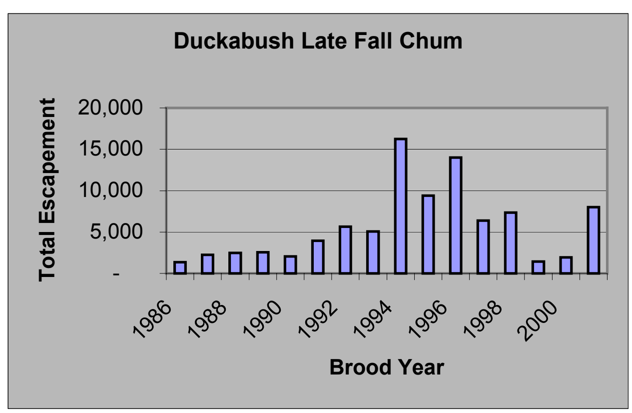

Figure 10. Duckabush Late Fall Chum Escapement. 1986 to 2001. Data provided by Thom Johnson, WDFW

through early January (WDFW, draft in review, 2003).

Data are total escapement estimates based on live/dead spawner counts in index areas on the Duckabush River, and Fulton and Pierce Creeks. Duckabush late fall chum escapements have been strong since the early 1990s, with two large numbers of returning adults in 1994 and 1996. In 1992 SASSI, the stock status was determined healthy. In 2002, SaSI also rates the stock **healthy** (WDFW, draft in review, 2003).

Hamma Hamma Late Fall Chum

Hamma Hamma late fall chum were determined a stock based on their geographic separation and somewhat late run and spawn timing. Most spawning occurs in the lower mile of the Hamma Hamma River and in John Creek, a tributary, from late November through early January. The stock is considered native with wild production.

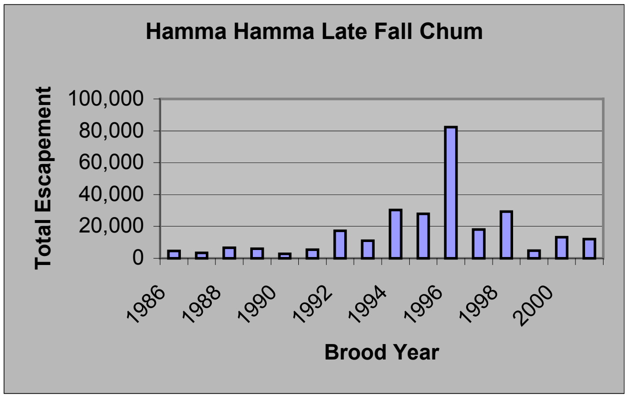

Figure 11. Hamma Hamma Late Fall Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW

Escapement estimates are based on live spawner counts in index areas on the Hamma Hamma and in John Creek. In 1992, SASSI rated the stock healthy. Late fall chum escapements have been strong since the early 1990s with one extraordinary escapement in 1996 with 82,297 fish. In 2002, SaSI rates the stock **healthy** (WDFW, draft in review, 2003).

West Hood Canal Fall Chum

West Hood Canal fall chum are considered a stock based on their distinct spawning distribution. Spawning occurs in numerous small, independent streams including (but not limited to) Jorsted, Eagle, Little Lilliwaup, Sund, Miller, Clark and Hill creeks. These spawning streams are close enough in proximity to allow gene flow among them (WDFW, draft in review, 2003). West Hood Canal Streams are genetically indistinguishable from Hoodsport Hatchery fall chum (Phelps et al. 1995 cited in WDFW, draft in review, 2003). It is considered a mixed stock with composite

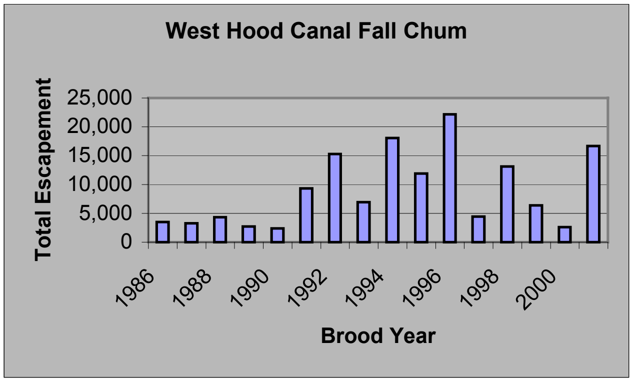

Figure 12. West Hood Canal Fall Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

production. Intense hatchery introductions and straying from the nearby Hoodsport Hatchery stock into these streams have probably either established introduced runs or impacted native chum such that they can no longer be distinguished from the hatchery stock (WDFW, draft in review, 2003).

Escapement estimates are based on live adult counts in index areas on Jorsted, Eagle, Little Lilliwaup, Sund, Miller, Clark, and Hill creeks. In 1992 SASSI determined the status to be healthy. Escapements declined during the 1980s but have been strong since the early 1990s. In 2002, SaSI rated the stock **healthy**.

Upper Skokomish Late Fall Chum

Upper Skokomish late fall chum were identified as a stock due to their special distribution, temporal differences and genetic composition. Spawning occurs from December through January in most tributaries of the Skokomish system below the Cushman Dam on the North Fork, with the highest concentration in the lower 4.7 miles. It is considered a native stock with wild production (WDFW, draft in review, 2003).

Escapement estimates are based on live adult counts in index areas on the North Fork Skokomish River, Richert Springs, Swift Creek and Vance Creek. In 1992, SASSI rated the stock healthy. Escapements have a long-term pattern of stability, with an increase in escapements in the 1990s. In 2002, SaSI continued with a **healthy** rating.

Lower Skokomish Fall Chum

Lower Skokomish fall chum were identified as a stock based on their distinct spawning distribution and early spawning timing compared with the timing for the Upper Skokomish late fall chum. Most spawning occurs in Purdy and Weaver creeks and in the lower mainstem Skokomish River from November through December. This is a mixed stock with composite production. George Adams hatchery (located on Purdy Creek, a lower Skokomish River tributary) and McKernan hatchery (located on Weaver Creek, another tributary to the lower Skokomish River) exchange fall chum eggs and receive eggs from Hoodsport hatchery when their egg take goals are not met. Repeated releases of Hoodsport hatchery fall chum into the lower Skokomish River may have significantly altered the genetic composition of the lower Skokomish fall chum stock (WDFW, draft in review, 2003).

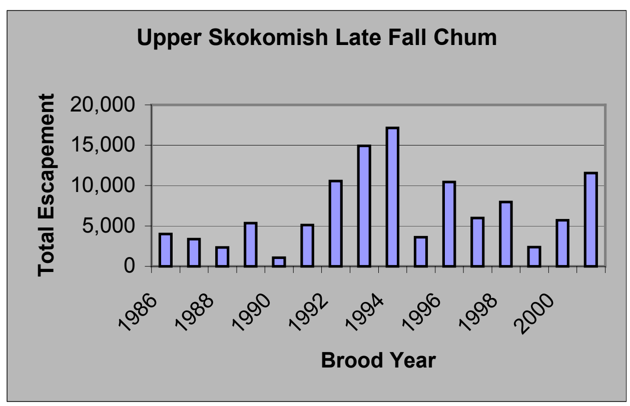

Figure 13. Upper Skokomish Late Fall Chum Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

In 1992 the status of the stock was unknown. Since there are still no abundance trend data for this stock, the status remains **unknown** in 2002. Many adult chum spawn in the lower Skokomish and its tributaries that most likely consists of a large number of strays from George Adams and McKernan hatcheries. Although quantitative data are lacking, the stock is probably healthy (WDFW, draft in review, 2003).

Coho *(Oncorhynchus kisutch)*

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Coho spawn from October to January and emerge in early March to late July. Most juvenile coho remain at lest one year in freshwater, although recent studies have shown that some strains spend time in estuaries prior to smoltification. Those that remain in freshwater rear in shallow gravel areas near the streambank or in side channels away from severe winter flows. They school at first but later disperse and become aggressive and territorial. Coho go through physiological changes (osmoregulation or smoltification), preparing for life in salt water, and migrate to sea in spring (Lichatowich 1993b). They spend one year at sea and return as three year old adults. Coho salmon in Hood Canal are managed on a wild stock basis.

Dosewallips Coho

Dosewallips coho were identified as a stock based on their geographic separation. No genetic analysis has been done on this stock. Most spawning takes place in the lower 12 miles of the mainstem Dosewallips and in side channels and small tributaries from early November to late December.

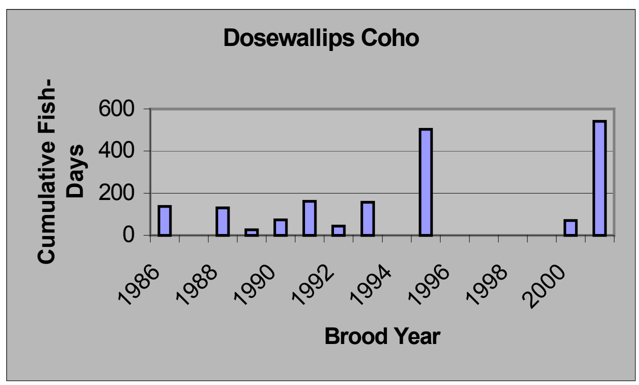

Figure 14. Dosewallips Coho Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on sum-of-season cumulative fish-days values for the index area between river mile 0.0 to 0.3 on Rockybrook Creek, a left bank tributary to the Dosewallips at approximately river mile 3.6. In 1992, SASSI rated the stock healthy. No data was collected in 1987, 1994, 1996, 1997, and 1999. No fish were observed in 1998. However, given that Rockybrook Creek index represents only a small part of the spawning habitat and is poor-quality habitat as well, these data are not considered a good representation of the total population. Consequently, in 2002, SaSI rated the stock **unknown**.

The stock is mixed composition with wild production. There were periodic releases of non-native yearlings between 1954 and 1980 utilizing Dungeness, Hood Canal, George Adams, Quilcene, Minter Creek and Green River hatchery stocks. George Adams fingerlings were released into this area in 1985 and 1986.

Duckabush Coho

Duckabush coho were identified as a stock due to their geographic separation. No genetic analysis has been completed on this stock. Spawning takes place mainly in the lower three miles of the mainstem Duckabush River. Spawning also occurs in Fulton Creek to the south of the Duckabush, Pierce Creek immediately to the north of the Duckabush and in Hatchery Creek, a lower Duckabush tributary. The time for spawning is generally between early November and early January.

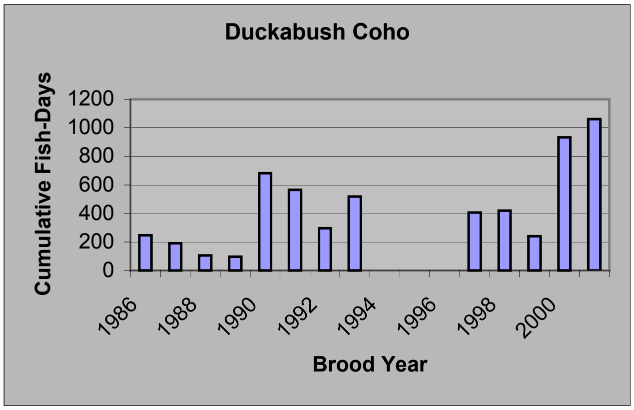

Figure 15. Duckabush Coho Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on sum-of-season cumulative fish-days values for Fulton Creek (river mile 0.0 to 0.8), Pierce Creek (river mile 0.0 to 0.5) and Hatchery Creek (river mile 0.0 to 1.0). No surveys were completed in 1994, 1995 or 1996. In 1992, SASSI rated the stock depressed. The 1997, 2000 and 2001 escapements were higher than the 1984 to 1989 escapement average, and the 2000 and 2001 values are the highest on record. Consequently, the 2002 SaSI changed the status to **healthy** (WDFW, draft in review, 2003).

Duckabush coho is a mixed stock with wild production. There were infrequent off-station releases of hatchery yearlings between 1954 and 1980 into the Duckabush utilizing Hood Canal, Quilcene, Green River, Minter Creek and Dungeness hatchery stocks. George Adams fingerlings were released into this system from 1984 through 1986 (WDFW, draft in review, 2003).

Hamma Hamma Coho

Hamma Hamma coho were identified as a stock based on their geographic separation. No genetic analysis has been done on this stock. Most spawning takes place in the lower two miles of the Hamma Hamma River and in the lower two miles of John Creek from early November to late December. This stock is likely a mixture of native and introduced non-native stocks. There have been sporadic releases of non-native hatchery yearlings between 1954 and 1980 into the mainstem. These releases utilized Hood Canal,

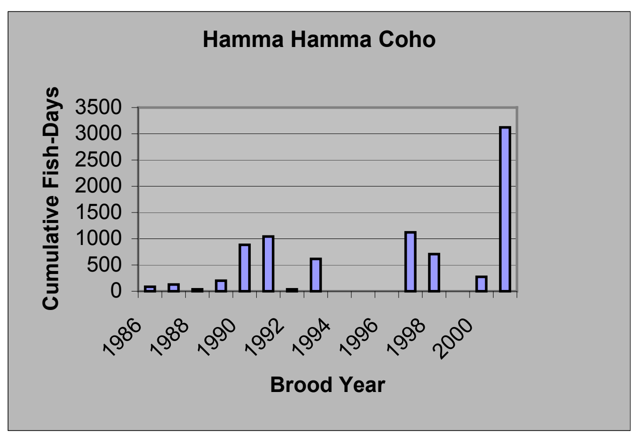

Figure 16. Hamma Hamma Coho Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Dungeness, Quilcene, Green River, Minter and George Adams Stocks. This mixed stock is now managed for wild production.

Escapement estimates are cumulative fish-days values for an index on John Creek (river mile 0.0 to 1.6. In 1992, SASSI rated this stock healthy. No data was collected in 1994, 1995, 1996, or 1999. Due to the sporadic data, 2002 SaSI rated this stock **unknown**.

Southwest Hood Canal Coho

Southwest Hood Canal coho were identified as a stock based on their distinct spawning distribution. No genetic analysis has been complete for this stock. Most spawning takes place in the independent tributaries between the Skokomish River and the Hamma Hamma River, including but not limited to Clark, Sund, Miller, Eagle, Jorsted and Little Lilliwaup creeks and the Lilliwaup River. Spawning time occurs between early November and late December.

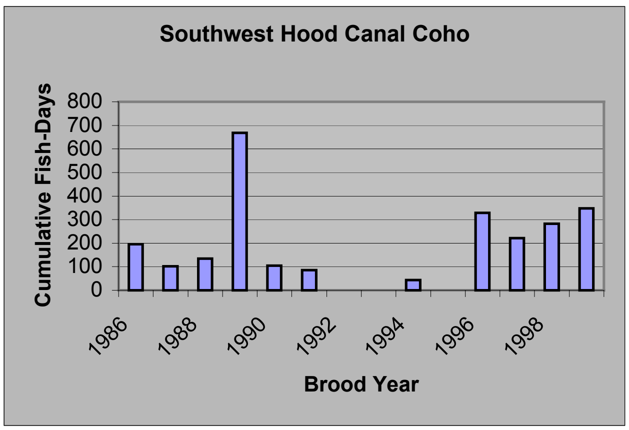

Figure 17. Southwest Hood Canal Coho Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are sum-of-season cumulative fish-days values for two index areas: Eagle Creek (river mile 0.0 to 1.2) and Jorsted Creek (river mile 0.0 to 0.7). In 1992, SASSI rated the stock healthy. No data was collected in 1986, 1987, 1994, 1995 or 1997. However, index escapement values for 1998, 1999 and 2000 are higher than the observed values for three of the four years from 1988 to 1991. Therefore, the 2002 SaSI reissued a **healthy** status (WDFW, draft in review, 2003).

Southwest Hood Canal coho is a mixed stock with wild production. There were sporadic releases of hatchery yearlings between 1954 and 1976 into these streams. These releases utilized Hood Canal, Dungeness and Quilcene stocks as well as Hoodsport and George Adams. From 1982 the emphasis at Hood Canal hatcheries has been on early-run production utilizing Sol Duc, Baker (Skagit River basin) and Capilano (Canada) stocks (WDFW, draft in review, 2003).

Skokomish Coho

Skokomish coho were identified as a stock based on their distinct spawning distribution. Allozyme analysis of North Fork Skokomish coho sampled in 1994 and 1995 showed them to be significantly different from all other Washington coho (David Teel, NWIFC, cited in WDFW, draft in review, 2003).

Escapement estimates are sum-of-season cumulative fish days values for index areas in the small Skokomish tributaries: Swift Creek (river mile 0.0 to 0.3), Kirkland Creek (river mile 0.0 to 0.9) and Fir Creek (river mile 0.0 to 0.3). Escapement estimates for the North Fork Skokomish index areas (river mile 12.0 to 15.6) began in 1993 and are expressed as cumulative fish-days values.

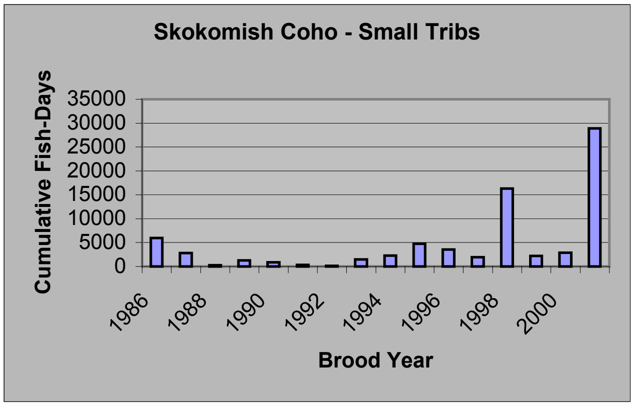

Figure 18. Skokomish Coho Escapement in Small Tribs, 1986 to 2001. Data provided by Thom Johnson, WDFW.

In 1992, SASSI rated the stock, as represented by the small tributaries, healthy. Spawner escapements have increased substantially since 1993. Additional surveys were begun in the North Fork Skokomish and most often ranged between 20,000 and 100,000 since 1994. This converts to about 2,000 to 5,000 adult coho in the 3.6 miles of the North Fork that are surveyed. In 2002, SaSI therefore rated the stock **healthy** (WDFW, draft in review, 2003).

This stock is likely a mixture of the native stock and introduced non-native stocks. There have been substantial releases of non-native coho fry and yearlings into this system, particularly from George Adams hatchery on Purdy Creek. There were several releases into Purdy Creek utilizing Quilcene, Samish Soos Creek, Hood Canal and Skykomish hatchery stocks with additions of Puyallup, Minter Creek and Sol Duc stocks. Fingerling/fry releases from 1958 to 1973 were primarily Hood Canal and George Adams stocks. Skokomish coho are managed for wild production (WDFW, draft in review, 2003).

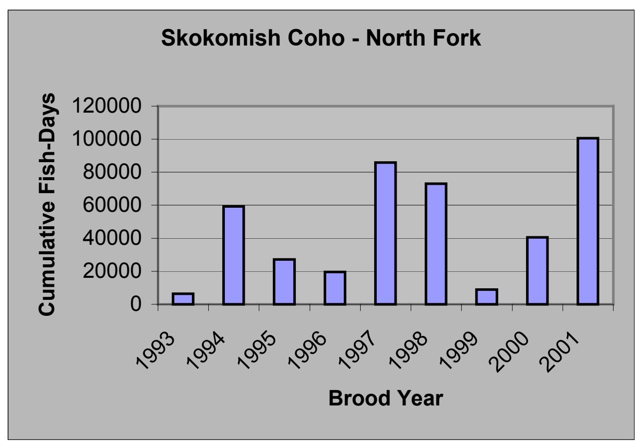

Figure 19. Skokomish Coho Escapement - North Fork, 1993 to 2001. Data provided by Thom Johnson, WDFW.

Pink Salmon *(Oncorhynchus gorbuscha)*

Pink salmon spawn from mid-July to late October and emerge late February to early May. Fry move downstream at night, immediately after emergence. The juveniles stay in the nearshore waters for several months, and then move offshore as they migrate out to the Pacific Ocean. Preferred foods include euphausiids, amphipods, fishes, squid, copepods and pteropods (Lichatowich 1993b). Pink salmon remain at sea for two years before returning to freshwater to spawn.

Hood Canal pink salmon return in odd years during September and October to spawn. Allozyme analysis has shown that the Dosewallips pinks, Hamma Hamma pinks and Duckabush pinks are not genetically distinct from each other but are significantly different from other Washington pink stocks (Shaklee 2001 cited in WDFW, draft in review, 2003). Given the distance between watersheds and the likelihood of reproductive isolation, separate stock status is given to each watershed (WDFW, draft in review, 2003).

Dosewallips Pink

Dosewallips pinks were identified as a stock based on their geographic separation. Most spawning takes place in the lower seven miles of the mainstem from September through early October. This is a native stock with wild production (WDFW, draft in review, 2003).

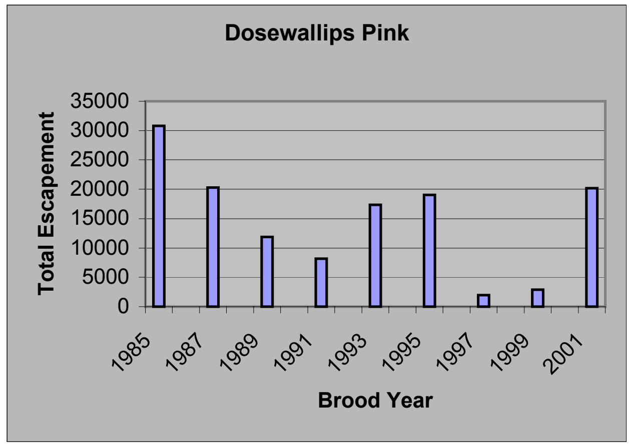

Figure 20. Dosewallips Pink Escapement, 1985 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on counts of live and dead spawners from river mile 0.0 to 6.7 in the mainstem. In 1992, SASSI rated the stock healthy. Between 1963 and 1967, pink escapements were between 125,000 to 400,000 spawners. More recently, escapements have declined to a range of 10,000 to 40,000, with two very low escapements of 1,954 and 2,903. Consequently, in 2002, SaSI rated the stock **depressed** due to chronically low escapements and a short-term severe decline in 1977 and 1999 (WDFW, draft in review, 2003).

Duckabush Pink

Duckabush pinks were identified as a stock due to geographic separation. Most spawning occurs in the lower two miles of the mainstem from September through early October. This is a native stock managed for wild production.

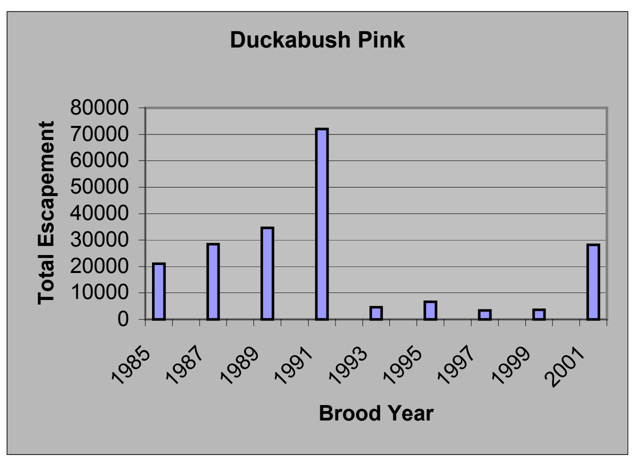

Figure 21. Duckabush Pink Escapement, 1985 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on counts of live and dead spawners from river mile 0.1 to 2.3 on the mainstem. In 1992 SASSI rated the stock healthy.

The escapements exceeded 20,000 adults each year between 1985 and 1992, peaking with 72,000 fish in 1991. Although estimated escapement increased in 2001, the 2002 SaSI rated the stock **depressed** due to chronically low escapements from 1993 to 1999 (WDFW, draft in review, 2003).

Hamma Hamma Pink

Hamma Hamma pinks were identified as a stock based on their geographic separation. Most spawning takes place in the lower two miles of the mainstem and in John Creek from September through early October.

Escapement estimates are total escapements based on counts of live and dead spawners from river mile 0.3 to 1.8 in the mainstem and from river mile 0.0 to 1.0 in John Creek. In 1992, SASSI rated this stock healthy. The escapements have been strong since 1983 with large escapements in 1991 and 2001. Stock status in 2002 SaSI is rated **healthy**.

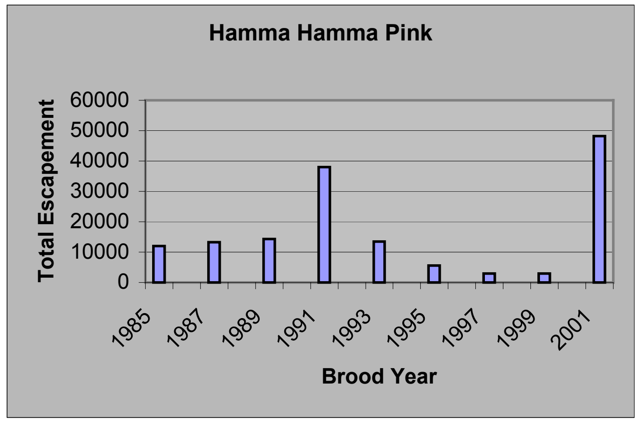

Figure 22. Hamma Hamma Pink Escapement, 1985 to 2001. Data provided by Thom Johnson, WDFW.

Steelhead *(Oncorhynchus mykiss)*

Steelhead is an anadromous form of rainbow trout with a unique life history. Unlike Pacific salmon, steelhead may return to sea after spawning and migrate again to freshwater to spawn again another year. There are two races of steelhead: summer and winter. Spawning for both races occurs from December to June. Fry emerge April through June in WRIA 16 and spend one to two years, and rarely three years, in fresh water (Thom Johnson, personal communication 2002). They migrate to sea in the spring. They spend one to two summers in the open ocean and feed on crustaceans, squid, herring and other fish (Lichatowich 1993b).

Summer Steelhead

Adult summer-run steelhead return to freshwater between April and October and enter the stream as immature fish. They tend to spawn earlier in the season than do the winter-run fish (Cooper and Johnson 1992).

Dosewallips Summer Steelhead

Dosewallips summer steelhead were identified as a stock based on their geographic separation and entry time into their natal stream. Specific spawning locations are unknown but are believed to be in the upper reaches. Spawn timing is also unknown but is believed to be from February through April. There has been no genetic analysis on this stock. Stock origin and production type are unresolved by the state and tribes (WDFW, draft in review, 2003).

There are no adequate abundance trend data for this stock. In 1992, SASSI determined the stock to be unknown. In 2002, SaSI continues with a rating of **unknown** (WDFW, draft in review, 2003).

Duckabush Summer Steelhead

Duckabush summer steelhead were identified as a stock based on their distinct spawner distribution and early entry into their natal stream. Specific spawning locations are unknown, but it is believed that they spawn in the upper reaches of the watershed. Spawning timing is also unknown but is thought to be from February through April. No genetic analysis has been done on this stock. Stock origin and production type are unresolved (WDFW, draft in review, 2003).

Abundance data is lacking for this stock. In 1992, the status of the stock was unknown and remains **unknown** in 2002 (WDFW, draft in review, 2003).

Skokomish Summer Steelhead

Skokomish summer steelhead were identified as a stock due to their geographic separation and early entry into the river. Specific spawning locations are unknown, but it is believed that spawning takes place in the upper reaches. Spawn timing is also unknown, but it is believed to be from February through April. There is no genetic analysis and stock origin and production type are unresolved by the state and tribes (WDFW, draft in review, 2003).

Escapement is not monitored in the Skokomish. The stock status in 2002 was therefore **unknown**, as it was in 1992.

Winter Steelhead

Adult winter-run steelhead return to freshwater from November to May and are usually in their final stage of maturity when entering their natal streams (Cooper and Johnson 2002).

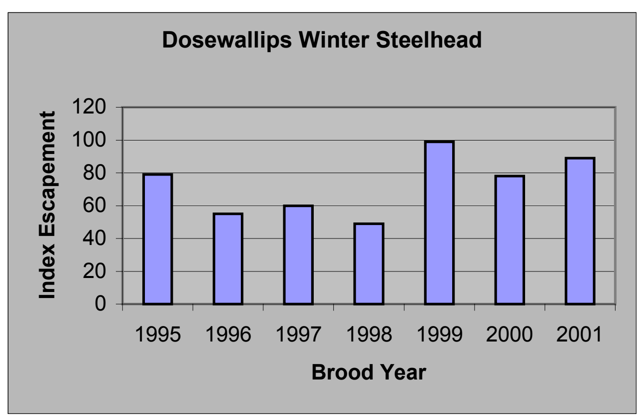

Figure 23. Dosewallips Winter Steelhead Escapement, 1995 to 2001. Data provided by Thom Johnson, WDFW.

Dosewallips Winter Steelhead

Dosewallips winter steelhead were identified as a stock based on the geographic separation and entry time into their natal stream. Most spawning takes place in the lower 12 miles of the Dosewallips River from mid-February to mid-June. Allozyme analysis indicates that Dosewallips steelhead appear to be distinct from other Hood Canal steelhead stocks (Phelps et al. 1977 cited in WDFW, draft in review, 2003).

Escapement estimates are based on redd counts in the index reach from river mile 0.2 to 12.0. In 1992 SASSI rated the stock depressed. In all the years surveyed, escapement has been lower than expected based on available habitat. Consequently, the stock status remained **depressed** in 2002 (WDFW, draft in review, 2003).

Duckabush Winter Steelhead

Duckabush winter steelhead were identified as a stock based on their geographic separation and entry time into their natal stream. Most spawning takes place in the lower four miles of the Duckabush River between Mid-February and mid-June. No genetic analysis has been completed for this stock (WDFW, draft in review, 2003).

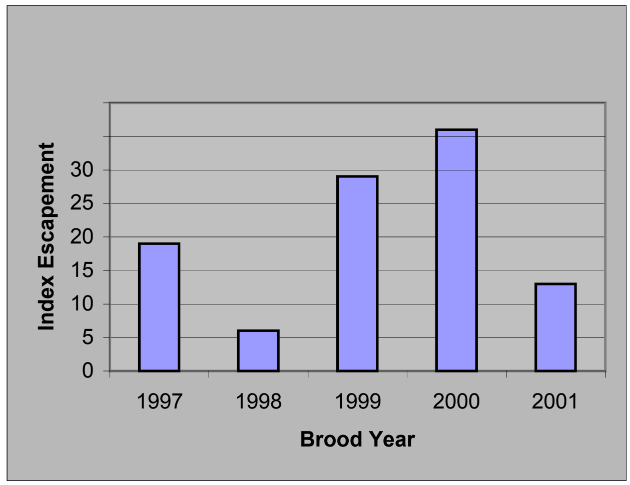

Figure 24. Duckabush Winter Steelhead Escapement, 1997 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on redd counts in the index are from river mile 0.0 to 2.6. In 1992 SASSI rated the stock depressed. In all years surveyed, escapement has been lower than expected based on available habitat. Therefore, the status remained **depressed** in 2002 (WDFW, draft in review, 2003).

Hamma Hamma Winter Steelhead

Hamma Hamma winter steelhead were identified as a stock based on the geographic separation and entry time into their natal stream. Most spawning takes place in the lower two miles of the mainstem between mid-February and mid-June. Genetic samples have been conducted on the stock but the results have not been compared to other Hood Canal stocks. However, the analysis has shown significant differences between resident rainbow parr and anadromous parr within the Hamma Hamma watershed (Berejikian et al. 2002 cited in WDFW, draft in review, 2003). This is a native stock with wild production.

Escapement estimates are based on index redd counts from river mile 0.3 to 1.8. In 1992 the status was unknown. In all years surveyed, escapement has been lower than expected based on available habitat. Consequently, the stock remained **depressed** in 2002 (WDFW, draft in review, 2003).

In 1998, Hood Canal Salmon Enhancement Group and Long Live the Kings, in cooperation with WDFW and the Tribes, initiated a steelhead supplementation program with the goal of rebuilding the native population. A portion of eggs in each redd are incubated in two strategies to reduce risk: some are taken to the Long Live the Kings facility on the Lilliwaup River and the rest are incubated in remote site incubators on John Creek. Release strategies are twofold: some are released as smolts and the rest are released as adults. Initial results are encouraging. Otolith evaluation has determined that the program contributed significantly to the 230 winter steelhead that spawned in the Hamma Hamma and John Creek in 2002; of these, 197 were adult steelhead released from the program (Thom Johnson, personal communication, 2003).

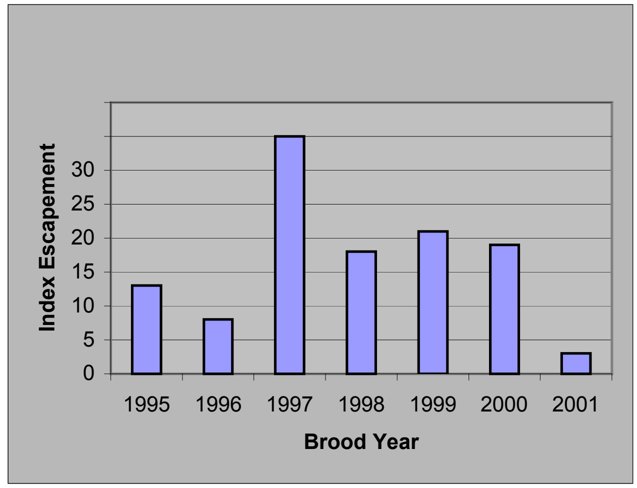

Figure 25. Hamma Hamma Winter Steelhead Escapement, 1995 to 2001. Data provided by Thom Johnson, WDFW.

Skokomish Winter Steelhead

Skokomish winter steelhead were identified as a separate stock based on their geographic separation. Most spawning takes place in the mainstem Skokomish and South Fork Skokomish with a smaller number in the North Fork Skokomish and Vance Creek between mid-February and mid-June. Allozyme analysis indicates that this stock appears to be distinct from other Hood Canal steelhead stocks (Phelps et al. 1977 cited in WDFW, draft in review, 2003).

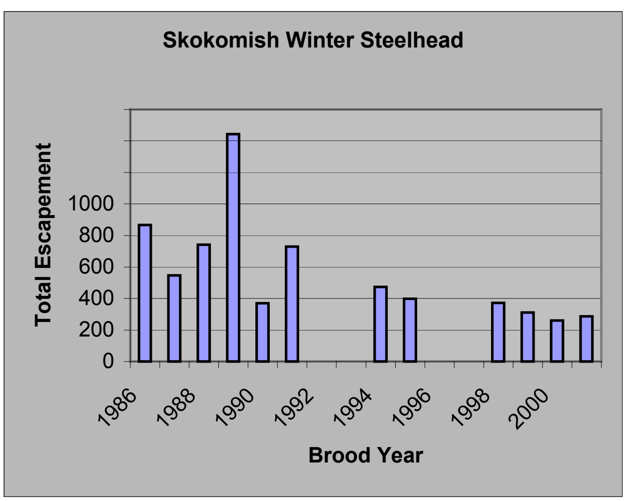

Figure 26. Skokomish Winter Steelhead Escapement, 1986 to 2001. Data provided by Thom Johnson, WDFW.

Escapement estimates are based on redd counts in index areas on the mainstem (river mile 0.0 to 9.0), in the North Fork Skokomish (river mile 9.0 to 13.0) and in the South Fork (river mile 0.0 to 21.4). In 1992, SASSI determined that the stock was depressed. In all the years but one (1989), escapements have been lower than expected based on available habitat. Surveys were conducted in 1992, 1993, 1996 and 1997, but escapement estimates were not possible due to poor visibility during high flows throughout the season. In 2002, SaSI again determined the stock to be **depressed** based on the long-term negative trend in escapement.

Sockeye *(Oncorhynchus nerka)*

Sockeye are unique in that they exhibit three life history strategies: one type spawns in rivers but rears in lakes for 1-3 years to complete their freshwater life cycle prior to migrating out to sea (lacustrine-adfluvial); one type spawns along lake shores and rears in lakes for 1-3 years prior to migrating out to sea (lacustrine); and one type spawns and rears in rivers and streams (fluvial). In WRIA 16, Sockeye are found in the Skokomish watershed only and are of the fluvial type. The population is not officially monitored but is observed spawning in the Skokomish mainstem and in the lower reaches of Vance Creek.

Kokanee, a landlocked sockeye salmon, are found in Cushman Reservoir. Whether there are remnant strains of the historic sockeye remains unknown. WDFW plants hatchery kokanee in the reservoir to supplement a sport fishery.

Bull Trout *(Salvelinus confluentus)*

Hood Canal bull trout are currently separated into three distinct stocks, all located within the Skokomish River Basin, but geographically separated from one another: South Fork Skokomish, Lake Cushman (Cushman Reservoir), and Upper North Fork Skokomish. Each stock is native. Historic USFWS hatchery records from the 1950s also place them in the Duckabush River (Marty Ereth, personal communication, 2002). Coastal-Puget Sound bull trout are now federally listed as threatened under the Endangered Species Act.

Skokomish River Bull Trout

Bull trout are found in the Upper North Fork, Cushman Reservoir and the South Fork Skokomish Rivers. Primary lacustrine-adfluvial bull trout spawning migration in the North Fork upstream of Lake Cushman occurs between October and early December when flows increase and water temperature decreases. The average length of bull trout in the North Fork is 55 cm with some lengths up to 81cm. The delayed spawning migration might be due to the larger size spawners

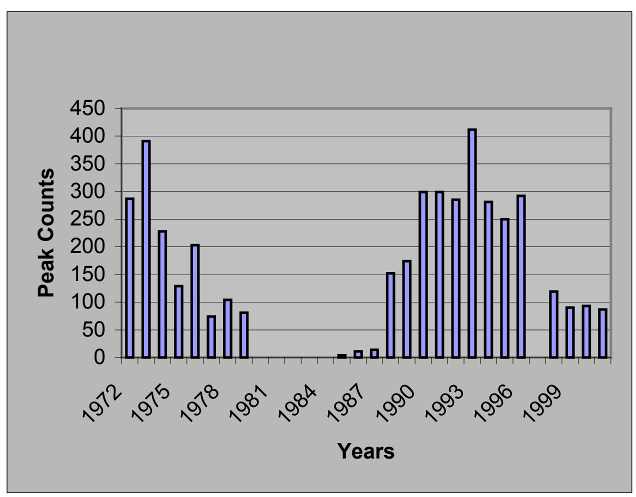

Figure 27. North Fork Skokomish Bull Trout Peak Counts, 1972 to 2001. Data provided by Thom Johnson, WDFW.

and their requirement for higher flows (Brenkman et al. 2001). Ages of bull trout from 44cm (17 inches) to 85cm (33 inches) ranged from three to 16 years old based on otolith analysis of fish collected in 1968 and 1969 (WDFW 1997). Naturally spawning populations are considered “native” with no history of stock transfers, introductions, or artificial propagation within the watershed. The status of the Lake Cushman stock, as indicated by WDFW, is rated healthy and the status of the Upper North Fork Skokomish is unknown (Thom Johnson, personal communication, 2002).

Fluvial bull trout have been observed in the South Fork Skokomish, particularly in LeBar and Brown Creeks, two left bank tributaries in the upper watershed. USFS staff monitors spawning grounds and conducts snorkel surveys in the South Fork. In 2000, 24 redds were counted, 20 redds in 2001 and 12 in 2002. Observation conditions were poor in 2002 due to high flows. In addition, snorkel surveys indicate one to two fish observed per mile of river surveyed. The USFS is estimating a population of 60 spawning fish. Otolith analysis indicates that this population is not anadromous (Larry Ogg, USFS, personal communication, 2003).

Rainbow Trout *(Oncorhynchus mykiss)*

Native rainbow trout, the resident form of steelhead, are found in the upper watersheds of the main river systems along western Hood Canal. Populations are not enumerated but have been observed in the Dosewallips, Duckabush, Hamma Hamma, Lilliwaup and Skokomish. WDFW plants rainbow trout each spring into Kokanee Reservoir for a sport fishery.

Fish Distribution

The Habitat Limiting Factors Analysis for WRIA 16 included mapping the distribution of chinook, chum, coho, pinks, steelhead/rainbow trout, sockeye and cutthroat at a 1:24,000 scale. Maps for each species (see Appendix A) were generated based on existing information from SASSI (WDFW and Tribes 1994), Streamnet, and WDFW and tribal spawner and juvenile surveys. In addition, members of the Technical Advisory Group added considerable professional knowledge to this effort. Mapping included known presence, presumed presence, and potential/historic presence. Following are two tables: a summary of stock status in WRIA 16 and a summary of fish distribution.

Table 1. Stock Status Summary

Species/Stock	1992 SASSI Status	2002 SaSI Status
Chinook		
Mid-Hood Canal	Not Rated	Critical
Skokomish	Not Rated	Depressed
Summer Chum		
Dosewallips	Not Rated	Depressed
Duckabush	Not Rated	Depressed
Hamma Hamma	Not Rated	Depressed
Lilliwaup	Not Rated	Critical
Finch	Not Rated	Extinct
Skokomish	Not Rated	Extinct
Fall Chum/Late Fall Chum		
Dosewallips	Healthy	Healthy
Duckabush	Healthy	Healthy
Hamma Hamma	Healthy	Healthy
West Hood Canal	Healthy	Healthy
Upper Skokomish	Healthy	Healthy
Lower Skokomish	Unknown	Unknown
Coho		
Dosewallips	Healthy	Unknown
Duckabush	Depressed	Healthy
Hamma Hamma	Healthy	Unknown
Southwest Hood Canal	Healthy	Healthy
Skokomish	Healthy	Healthy
Pink Salmon		
Dosewallips	Healthy	Depressed
Duckabush	Healthy	Depressed
Hamma Hamma	Healthy	Healthy
Summer Steelhead		
Dosewallips	Unknown	Unknown
Duckabush	Unknown	Unknown
Skokomish	Unknown	Unknown
Winter Steelhead		
Dosewallips	Depressed	Depressed
Duckabush	Depressed	Depressed
Hamma Hamma	Unknown	Depressed
Skokomish	Depressed	Depressed

Table 2. Summary of known fish distribution in WRIA 16, 2003. Table provided by Jennifer Cutler, NWIFC.

Stream Segment	Species Present*							Known Use (Miles)**
	Chin	*FChum*	*SChum*	*Pink*	*Coho*	*Sock*	*Sthd*	
Dosewallips Subbasin								
Turner Creek		x			x			1.1
Dosewallips River - Mouth to Rocky Brook	x	x	x	x	x		x	5.6
Dosewallips River - Rocky Brook to falls at RM 12.5	x	x		x	x		x	11.4
Dosewallips River - Above falls at RM 12.5								0.0
Rocky Brook Creek	x	x		x	x		x	0.4
Walker Creek		x			x			0.2
Dosewallips Subbasin Total	x	x	x	x	x		x	18.7
Duckabush Subbasin								
Duckabush River - Mouth to RM 5	x	x	x	x	x		x	7.1
Duckabush River - RM 5 to falls at RM 8	x				x		x	1.5
Duckabush River - Above the falls at RM 8								0.0
Duckabush Subbasin Total	x	x	x	x	x		x	8.6
Hamma Hamma Subbasin								
McDonald Creek		x			x			0.5
Fulton Creek		x		x	x			1.1
Shaerer Creek		x			x			0.1
Unnamed Creek - Mikes Beach								0.0
Waketickeh Creek		x			x			0.3
Hamma Hamma River - Mouth to canyon at RM 1.5	x	x	x	x	x		x	1.7
Hamma Hamma River - RM 1.5 to falls at RM 2.3	x	x		x	x		x	0.7
Hamma Hamma River - Above the falls at RM 2.3								0.0
Johns Creek	x	x	x	x	x		x	2.1
Hamma Hamma Subbasin Total	x	x	x	x	x		x	6.5
Lilliwaup Subbasin								
Jorsted Creek/Ayock Creek		x			x			1.0
Eagle Creek	x	x			x		x	2.9
Lilliwaup Creek - Mouth to falls at RM 0.7	x	x	x	x	x		x	0.3
Lilliwaup Creek - Above the falls at RM 0.7								0.0

Stream Segment	Species Present*							Known Use (Miles)**
	Chin	*FChum*	*SChum*	*Pink*	*Coho*	*Sock*	*Sthd*	
Little Lilliwaup Creek		x			x			0.5
Sund Creek/Miller Creek		x			x			0.9
Clark Creek		x			x			0.3
Finch Creek		x		x	x		x	0.3
Hill Creek	x	x***		x	x			0.0
Lilliwaup Subbasin Total	x	x	x	x	x		x	6.2
Skokomish Subbasin								
Canal Side Diner Creek		x***			x***			0.0
Minerva Creek/Potlatch Creek		x			x			0.1
Enetai Creek	x	x			x			0.9
Skokomish River - Mouth to forks at RM 9	x	x		x	x	x	x	28.6
Purdy Creek	x	x		x	x		x	2.8
Weaver Creek	x	x			x		x	2.2
Hunter Creek	x	x			x		x	3.4
Richert Springs	x	x			x			1.5
North Fork Skokomish - Mouth to Kokanee Dam	x	x		x	x		x	8.1
North Fork Skokomish - Above Kokanee Dam	x							12.7
McTaggert Creek	x	x			x			3.8
South Fork Skokomish - Mouth to RM 3	x	x		x	x	x	x	3.6
South Fork Skokomish - RM 3 to RM 10	x	x		x	x		x	8.0
South Fork Skokomish - RM 10 to falls at RM 23.5	x				x		x	15.1
South Fork Skokomish - Above falls at RM 23.5								0.0
Vance Creek	x	x		x	x	x	x	10.9
Flat Creek/Rock Creek								0.0
Brown Creek							x	3.0
LeBar Creek								0.0
Cedar Creek							x	0.7
Pine Creek							x	0.7
Church Creek							x	0.7
Skokomish Subbasin Total	x	x		x	x	x	x	106.8
WRIA 16 Total	x	x	x	x	x	x	x	146.8

Stream Segment	Species Present*							Known Use (Miles)**
	Chin	*FChum*	*SChum*	*Pink*	*Coho*	*Sock*	*Sthd*	

*Species Present indicates known use in the subbasin or stream as of March 2003. Lack of presence in this table does not indicate that a particular species is absent from the subbasin or stream. Chin = chinook, FChum = fall chum, SChum = summer chum, Sock = sockeye ,Sthd = steelhead.
**Known use is the stream length in miles with chinook, fall chum, summer chum, pink, coho, sockeye or steelhead use identified as of March 2003.
***Added after fish distribution mapping was completed.

INTRODUCTION TO HABITAT LIMITING FACTORS

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and large woody debris (LWD). These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors. Provided first though, is a general description of the current and historic habitat including salmon populations.

Discussion of Habitat Limiting Factor Elements

(Section Author, Don Haring, WCC/WDFW)

Fish Passage Barriers

Salmon are limited to certain spawning and rearing locations by natural features of the landscape. These features include channel gradient and the presence of physical features of the landscape (e.g. logjams). Flow can affect the ability of some landscape features to function as barriers. For example, some falls may be impassable at low flows, but then become passable at higher flows. In some cases flows themselves can present a barrier, such as when extreme low flows occur in some channels; at higher flows fish are not blocked. Flow conditions may also allow accessibility to some anadromous salmonid species, while precluding access to others.

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible habitat. The most obvious of these barriers are dams and diversions with no passage facilities that prevent adult salmon from accessing historically used spawning grounds. However, in recent years it has become increasingly clear that we have also constructed barriers that prevent juveniles from accessing rearing habitat. For example, in estuarine areas, dikes and levees have blocked off historically accessible estuarine areas such as tidal marshes, and poorly designed culverts in streams have impacted the ability of coho juveniles to move upstream into rearing areas. This chapter highlights known human-caused barriers to salmon and steelhead trout.

Floodplains

Floodplains are portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. In general, most floodplain areas are located in lowland areas of river basins and are associated with higher order streams. Floodplains are typically structurally complex, and are characterized by a great deal of lateral, aquatic connectivity by way of distributaries, sloughs, backwaters, side channels, oxbows, and lakes. Often, floodplain channels can be highly braided (multiple parallel channels).

One of the functions of floodplains is to provide aquatic habitat. Aquatic habitats in floodplain areas can be very important for some species and life stages such as coho salmon juveniles that often use the sloughs and backwaters of floodplains to overwinter since this provides a refuge from high flows. Floodplains also help dissipate water energy during floods by allowing water to escape the channel and inundate the terrestrial landscape, lessening the impact of floods on incubating salmon eggs. Floodplains also provide coarse beds of alluvial sediments through which subsurface flow passes. This acts as a filter of nutrients and other chemicals to maintain high water quality. Floodplains also provide an area for sediment deposition and storage, particularly for fine sediment, outside of the river channel, reducing the effects of sediment deposition and instability in the river channel.

Large portions of the floodplains of many Washington rivers, especially those in the western part of the state, have been converted to urban and agricultural land uses. Much of the urban areas of the state are located in lowland floodplains, while land used for agricultural purposes is often located in floodplains because of the flat topography and rich soils deposited by the flooding rivers.

There are two major types of human impacts to floodplain functions. First, channels are disconnected from their floodplain. This occurs both laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. This has:

1) eliminated off-channel habitats such as sloughs and side channels, 2) increased flow velocity during flood events due to the constriction of the channel, 3) reduced subsurface flows and groundwater contribution to the stream, and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed. Channels can also become disconnected from their floodplains as a result of downcutting and incision of the channel from losses of LWD, decreased sediment supplies, and increased high flow events.

The second major type of impact is loss of natural riparian and upland vegetation. The natural riparian and terrestrial vegetation in floodplain areas was historically coniferous forest. Conversion of these forested areas to impervious surfaces, deciduous forests, meadows, grasslands, and farmed fields has occurred as floodplains have been converted to urban and agricultural uses. Loss of vegetation on the floodplain reduces shading of water in floodplain channels, eliminates LWD contribution, reduces filtering of sediments, nutrients and toxics, and results in increased erosional energy during flood flows.

Elimination of off-channel habitats, such as sloughs and backwaters, results in the loss of important habitats for juvenile salmonids. These habitats function as prime spawning habitat for chum, pink, and coho as they are protected from flood flow impacts, and they provide rearing and overwintering habitat for coho juveniles. The loss of LWD from channels also reduces the amount of rearing habitat available for chinook juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg to fry survival due to the scour. Removal of riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality.

Sediment Supply

The sediments present in an ecologically healthy stream channel are naturally dynamic and are a function of a number of processes, which input, store, and transport the materials. Processes naturally vary spatially and temporally and depend upon a number of features of the landscape such as stream order, gradient, stream size, basin size, geomorphic context, and hydrological regime. In forested mountain basins, sediment enters stream channels from natural mass wasting events (e.g. landslides and debris flows), channel bank erosion (particularly in glacial deposits), surface erosion, and soil creep. Inputs of sediment to a stream channel in these types of basins naturally occurs periodically during extreme events such as floods (increasing erosion) and mass wasting which are the result of climatic events (e.g., rainstorms, rain on snow). In lowland, or higher order streams, erosion is the major natural sediment source. Inputs of sediment in these basins tend to be steadier in geologic time.

Once sediment enters a stream channel it can be stored or transported depending upon particle size, stream gradient, hydrological conditions, availability of storage sites, and channel type or morphology. Finer sediments tend to be transported through the system as wash load or suspended load, and have relatively little effect on channel morphology. Coarser sediments (>2 mm diameter) tend to travel as bedload, and can have larger effects on channel morphology as they move downstream, depositing through the channel network.

Some parts of the channel network are more effective at storing sediment, while other parts of the network are more effective at transporting material. There are also strong temporal components to sediment storage and transport, such as seasonally occurring floods, which tend to transport more material. One channel segment may function as a storage site during one time of year and a transport reach at other times. In general, the coarsest sediments are found in upper watersheds while the finest materials are found in the lower reaches of a watershed. Storage sites include various types of channel bars, floodplain areas, and behind LWD.

Changes in the supply, transport, and storage of sediments can occur as the direct result of human activities. Human actions can result in increases or decreases in the supply of sediments to a stream. Increases in sediment deposition in the channel result from increased erosion due to land use practices, or isolation of the channel from the floodplain (diking and roading), which eliminates important off-channel storage areas for sediment and increases the sediment load beyond the transport capacity of the stream. In addition, actions that destabilize the landscape in high slope areas such as logging or road construction increase the frequency and severity of mass wasting events. Finally, increases in the frequency and magnitude of flood flows, and/or loss of floodplain vegetation, increase erosion. These increases in coarse materials fill pools and aggrade the channel, resulting in reduced habitat complexity and reduced rearing capacity for some salmonids. Increase in total sediment supply to a channel increases the proportion of fine sediments in the bed, which can reduce the survival of incubating eggs in the gravel and change benthic invertebrate production.

Decreases in sediment supply occur in some streams. This occurs primarily as a result of disconnecting the channel from the floodplain. A dam can block the supply of sediment from upper watershed areas while a levee can cut off upland sources of sediment. In addition, gravels are removed from streambeds to increase flow capacity (dredging) or for mineral extraction purposes. Reduction in sediment supply can alter the streambed composition, which can coarsen the substrate and reduce the amount of material suitable for spawning.

In addition to affecting sediment supply, human activities can also affect the storage and movement of sediment in a stream. An understanding of how sediment moves through a system is important for determining where sediment will have the greatest effect on salmonid habitat and for determining which areas will have the greatest likelihood of altering habitats. In general, transport of sediment changes as a result of gradient, hydrology changes (water removal, increased peak flows, or altered timing and magnitude of peak flows), and isolation of the channel from its floodplain. This increases in the magnitude and frequency of flood flows. Larger and more frequent flood flows move larger and greater amounts of material more frequently. This can increase bed scour, bank erosions, and alter channel morphology, and ultimately degrade the quality of spawning and rearing habitat. Unstable channels become very dynamic and unpredictable compared to the relatively stable channels characteristic of undeveloped areas. Additional reductions in the levels of instream LWD can greatly alter sediment storage and processing patterns, resulting in increased levels of fines in gravels and reduced organic material storage and nutrient cycling.

Riparian Zones

Stream riparian zones include the area of living and dead vegetative material adjacent to a stream. They extend from the edge of the average high water mark of the wetted channel toward the uplands to a point where the zone ceases to have an influence on the stream channel. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and where the channel is located in the drainage network. Large-scale natural disturbances (fires, severe windstorms, and debris flows) can dramatically alter riparian characteristics. These natural events are typically infrequent, with recovery to healthy riparian conditions for extended periods of time following the disturbance event. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a basin unimpacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Functions of riparian zones include providing hydraulic diversity, adding structural complexity, buffering the energy of runoff events and erosive forces, moderating temperatures, and providing a source of nutrients. They are especially important as the source of LWD in streams, which directly influences several habitat attributes important to anadromous species. In particular, LWD helps form and maintain the pool structure in streams, and provides a mechanism for sediment and organics sorting and storage upstream and adjacent to LWD formations. Pools provide a refuge from predators and high-flow events for juvenile salmon, especially coho that rear for extended periods in streams.

All types of land use practices impact riparian zones. In general, riparian forests can be completely removed, broken longitudinally by roads and laterally by bridges and culverts, and their widths can be reduced by land use practices. Further, species composition can be dramatically altered when exotic species, shrubs, and deciduous species replace native, coniferous trees. Deciduous trees are typically of smaller diameter than coniferous forests and decompose faster than conifers, so they do not persist as long in streams and are vulnerable to washing out from lower magnitude floods. Once impacted, the recovery of a riparian zone can take many decades as the forest cover regenerates and coniferous species colonize.

Changes to riparian zones affect many attributes of stream ecosystems. For example, stream temperatures can increase due to the loss of shade, while streambanks become more prone to erosion due to elimination of the trees and their associated roots. Perhaps the most important impact of riparian changes is a decline in the frequency, volume, and quantity of LWD due to altered recruitment from forested areas. Loss of LWD results in a significant reduction in the complexity of stream channels including a decline of pool habitat, which reduces the number of rearing salmonids. Pools also provide resting areas and cover for adults that are migrating prior to spawning. Loss of LWD affects the amount of both overwintering and low flow rearing habitat, as well as providing a variety of other ecological functions in the channel.

Hydrology

The hydrologic regime of a drainage basin refers to how water is collected, moved and stored. The frequency and magnitude of floods in streams are especially important since floods are the primary source of disturbance in streams and thus play a key role in how channels are structured and function. In ecologically healthy systems, the physical and biotic changes caused by natural disturbances are not usually sustained, and recovery is rapid to pre-disturbance levels. If the magnitude of change is sufficiently large, however, permanent impacts can occur.

Alterations in basin hydrology are caused by changes in soils, decreases in the amount of forest cover, increases in impervious surfaces, elimination of riparian and headwater wetlands, and changes in landscape context. Hydrologic impacts to stream channels occur even at low levels of development (<2% impervious surfaces) and generally increase in severity as more of the landscape is converted to urban or open uses.

Salmonid production is profoundly affected by water withdrawals for irrigation, industrial, and domestic use, including water transfers between basins. Removal of water either directly from the stream channel or from wells that are in hydraulic continuity with stream flows reduces the amount of instream flow and wetted useable area remaining for support of adult salmonid spawning and juvenile rearing. The relationship between the wetted useable area of a stream and stream flow varies between species and life stages. For example, juvenile coho prefer quiet water in pools for rearing, whereas juvenile steelhead prefer areas of faster water (Hiss and Lichatowich 1990). Impacts are typically greatest during the dry summer and early fall months when stream flows are lowest. In other instances stream flows may actually increase due to direct or indirect (irrigation ground water return flows) water transfers from other basins. In some instances peak flood flows may be transferred to basins that would otherwise not be affected by flood flows. These situations may increase the stream flow and wetted useable area for fish use, but the increased hydrology may cause channel bedload movement, bank erosion, loss of LWD, and other adverse habitat impacts that would not be experienced under the natural hydrology regime to which the channel is adapted.

Estuarine Habitat

Worldwide, few other habitats are so valuable for fish production and yet are so imperiled as estuaries. Estuaries include the area from the uppermost extent of tidal influence within the stream to the upper intertidal line on the delta face, although fresh water inputs at larger stream/river deltas certainly influence habitats physically and chemically at the lower intertidal margin. Their abundant food supply, wide salinity gradients, and diverse habitats make these areas particularly valuable to anadromous fish for rearing, feeding, and osmoregulatory acclimatization during transition between fresh water and marine habitats.

HABITAT LIMITING FACTORS BY SUB-BASIN

For the purpose of the limiting factors analysis, Water Resource Inventory Area (WRIA) 16 was divided into subbasins delineated as follows:

- Dosewallips (Turner, Dosewallips, Walker)
- Duckabush (Duckabush)
- Hamma Hamma (McDonald, Fulton, Schaerer, Waketickeh, Hamma Hamma)
- Lilliwaup (Jorsted, Eagle, Lilliwaup, Little Lilliwaup, Sund, Miller, Clark, Finch, Hill, Enetai, Minerva, Potlatch)
- Skokomish

The habitat elements considered by the Technical Advisory Group (TAG) for the WRIA 16 habitat limiting factors analysis include:

- Fish Access (artificial physical fish passage barriers)
- Floodplain Modifications (constrictions, loss of floodplain connectivity, loss of side channel habitat, loss of riparian and natural floodplain habitat)
- Channel Condition (fine sediment, large woody debris, pool quantity/quality, streambank stability)
- Sediment Input (sediment supply, mass wasting, road density)
- Riparian Condition (canopy closure/shade, bank stability, LWD recruitment)
- Water Quality (temperature, dissolved oxygen, total suspended solids)
- Hydrology (flows, hydrologic maturity, impervious surface)
- Biological Processes (fish carcass nutrients)
- Estuarine Condition
- Nearshore Condition

A list of data needs and action recommendations follows the discussion. A table with the TAG ratings for designated stream reaches can be found in Table 16.

DOSEWALLIPS SUB-BASIN

The Dosewallips watershed, located in southeast Jefferson County, lies in the northern portion of WRIA 16 with the Big Quilcene and Dungeness watersheds to the north and the Duckabush watershed to the south. The Dosewallips sub-basin includes Turner Creek (WRIA 16.0559), the Dosewallips River (WRIA 16.0442), and Walker Creek (WRIA 16.0441) for a total of 172.8 stream miles (Williams et al. 1975). The TAG evaluated the following reaches:

- Turner Creek, entire watershed
- Dosewallips River, mouth to Rocky Brook Creek at river mile 3.6
- Dosewallips River, Rocky Brook Creek to the falls at river mile 12.5
- Dosewallips River, above the falls
- Rocky Brook, left bank tributary to Dosewallips at river mile 3.6
- Walker Creek, entire watershed

Turner Creek

Turner Creek, an independent tributary to Hood Canal north of the Dosewallips River, is 1.15 miles long (Williams et al. 1975) with fish habitat extending approximately 0.8 miles (TAG 2002). The watershed encompasses 1,986 acres, or 3.1 square miles (May 2003). Average annual rainfall is approximately 53.9 inches (May 2003).

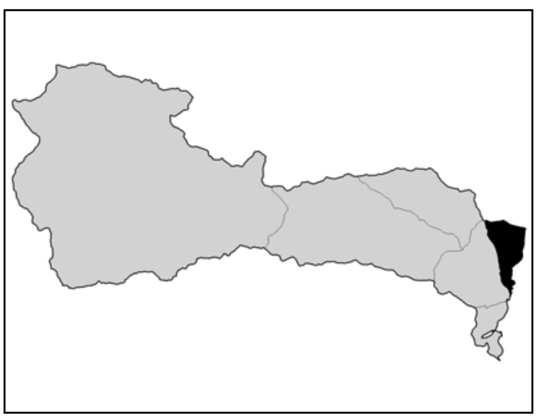

Figure 28. Turner Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Little habitat information is available for analysis. Habitat and fish distribution surveys are lacking in this drainage but it is included in the Dosewallips Watershed Analysis in association with Walker Creek (USFS 1999). WDFW barrier assessments on federal, state and county roads was used to assess fish access (Johnson et al. 2001). The TAG further contributed to barrier assessment during their 2002 fish distribution exercise. Jefferson County has digitized impervious surface from Landsat imagery for their refugia work (May 2003). The Department of Natural Resources' 2000 aerial photos were examined for floodplain and riparian condition.

Access and Passage

Artificial Barriers

A culvert barrier near the mouth of Turner Creek at Highway 101 prohibits anadromous fish utilization of the watershed (Johnson et al. 2001). It is presumed that cutthroat are present (TAG 2002).

Floodplains

Floodplain Connectivity

This parameter is a data gap

Loss of Floodplain Habitat

The ratio of the perimeter of the floodplain to the area of floodplain is large. It is a small stream that is fairly steep and confined with little floodplain habitat. Review of aerial photos revealed limited channel disturbance. However, according to the Jefferson County refugia study, the floodplain habitat has been 51% modified (May 2003).

Channel Condition

Fine Sediment/Large Woody Debris/Pool Data/Streambank Stability

All channel condition parameters are data gaps.

Sediment Input

Sediment Supply

This parameter is a data gap.

Mass Wasting

The Dosewallips Watershed Analysis (USFS 1999) combines Turner Creek and Walker Creek in their look at mass wasting potential, rating them high in susceptibility to shallow mass wasting events. Actual mass wasting analysis for Turner Creek has not been completed. Given the high susceptibility, there could be some undetected problems occurring (TAG 2003).

Road Density

Watershed analysis combined Turner Creek with Walker Creek in their road density evaluation and reported a total of 4.6 miles of road per square mile of watershed (USFS 1999).

Riparian Zones

Riparian Condition

The forested extent within the riparian buffer is 91% with 3.29 breaks in the canopy per stream mile. Conifer/mixed forest composition is 91% (May 2003).

Water Quality

Temperature/Dissolved Oxygen

These parameters are data gaps.

Hydrology

Flow: Hydrologic Maturity

Turner and Walker creeks combined have approximately 105 acres (7%) in forests under 20 years of age, 1,303 acres (88%) in forests between the age of 21 and 80, 56 acres (4%) in forests between 80 and 200 years old, and only 13 acres (1%) in forests over 200 years old (USFS 1999).

Flow: Percent Impervious Surface

Approximately 0.19% of the watershed is impervious surface (May 2003).

Biological Processes

Nutrients (Carcasses)

A culvert near the mouth of Turner Creek restricts anadromous fish access to the watershed. Therefore, biological processes driven by the decay and consumption of salmon carcasses have been largely eliminated from the watershed.

Data Needs

- Conduct habitat surveys to collect channel condition data: large woody debris, percent and frequency of pools, pool quality and streambank stability
- Collect water quality data

Action Recommendations

- Correct fish passage barrier at Highway 101

Dosewallips River

The Dosewallips River originates in the snowfields near Sentinel Peak and Mount Claywood in the Olympic Mountains and flows in a general eastward direction into Hood Canal near the town of Brinnon. Alluvial and glacial valley bottoms and relatively gentle slopes dominate the eastern part of the watershed, which steepens into rugged terrain with near vertical slopes and incised valley side slopes in the headwaters to the west. The western headwaters are wide glacial valleys with an average slope of 4% (USGS 1998, cited in USFS 1999). The watershed covers an area of approximately 78,000 acres or 122 square miles (USFS 1999).

The entire Dosewallips mainstem is approximately 28.3 miles in length with many tributaries contributing an additional 140 miles. Overall the gradient is steep with precipitous slopes and canyon walls. Many of the tributaries are steep yet still provide good spawning and rearing habitat in their lower reaches (May 2003). Average annual discharge is 446 cubic feet per second (cfs) with a range between 67 and 13,200 between 1931 and 1948. The gaging station is at river mile 7.1. There are two annual runoff peaks, one associated with winter rains between November and February and the other associated with snowmelt between May and June (USFS 1999). The upper 60 percent of the watershed is protected in Olympic National Park, the middle 30 percent lies within Olympic National Forest and the lower ten percent is dominated by residential development, pastureland and clearcut logging (WDFW and PNPTT 2000).

Disturbance to the existing vegetation in the watershed continues. The most extensive is timber harvest, which within the last five years has been concentrated on private lands. Insects and pathogens continue their impacts, though in a dispersed manner that is not obvious to the casual observer. Fire has had a minor impact in recent years with little activity. Wind occasionally blows down small stands of trees, primarily adjacent to recently harvested areas. Invasion of non-native plant species include bull thistle and tansy ragwort (USFS 1999).

Port Gamble S'Klallam Tribe has completed modified TFW ambient monitoring surveys in the Dosewallips River mainstem, as well as side-channels and tributaries. For the mainstem, ground surveys are being coupled with remote sensing techniques to provide a whole-river perspective on the distribution of large wood and pools. For this analysis, only data summaries of large wood are available for ground surveys of the river mainstem, while large wood and pool data summaries are available for side-channels and tributaries (Ted Labbe, personal communication, 2003). Washington Department of Fish and Wildlife culvert inventories were used to assess barriers on federal highways, state highways and county roads (Johnson et al. 2001). The TAG added to this effort during their fish distribution exercise in 2002. US Forest Service conducted a watershed analysis in 1999, which provided evaluation of hydrologic maturity of Turner, Walker and Rocky Brook creeks as well as mass wasting analysis (USFS 1999). Jefferson County has completed their refugia study, which contributed impervious surface information (May 2003). Where appropriate, the TAG contributed best professional knowledge. The remaining parameters are data gaps.

Dosewallips River – mouth to Rocky Brook at river mile 3.6

Gradient is moderate with a stable, confined channel through this lower reach, opening to a short alluvial valley near the mouth (Williams et al. 1975). The broad floodplain has been converted to agriculture (3 %), forestry (3%), urban commercial (6%), and rural residential (7%). Dosewallips State Park lies on the south side of the river and estuary and the town of Brinnon is to the north. Both are within the floodplain-delta area. Average annual rainfall is 55.6 inches (May 2003).

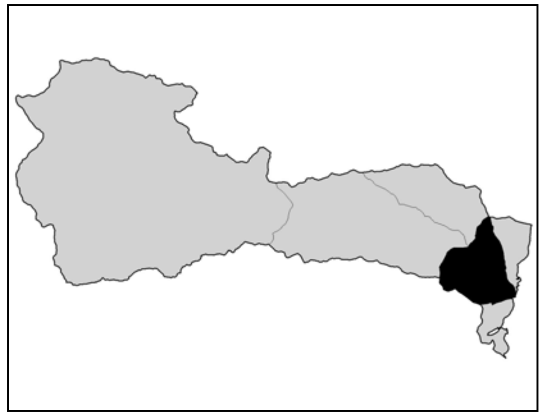

Figure 29, Dosewallips Watershed, Mouth to RM 3.6. Map provided by Jennifer Cutler. NWIFC.

Access and Passage

Artificial Barriers

There are no artificial barriers to fish migration on the mainstem. A county road extends along the left bank of the river throughout this entire reach. A WDFW inventory of county roads indicates no known barriers on fish bearing streams. The US 101 causeway restricts estuary function and has disconnected some of the side channels (see estuary section). A perched culvert (approximately 6.5-foot drop) on an independent tributary immediately to the south of the mouth of the Dosewallips is a barrier. Chum have been observed downstream of the culvert. The road is an access road used by Bonneville Power Administration and Washington State Parks. Quality of the habitat upstream of the barrier is unknown. This tributary, locally known as State Park Creek, could have historically connected with the lower Dosewallips River (Ted Labbe, personal communication, 2003).

Floodplains

Floodplain Connectivity

Access to side channels and floodplain wetlands has been eliminated in this reach due to rural residential development and agriculture activities (WDFW and PNPTT 2000). Diking in the lower mile and again associated with the left-bank Lazy C housing development at river mile 2.0 limits flooding access to the floodplain and riprap protects the dikes and unstable banks. Between these two sections the floodplain narrows and connectivity with side channels and wetlands remains intact (TAG 2003).

Loss of Floodplain Habitat

Beginning in the late 1800s, the lower river valley was converted from a forested floodplain, rich in large woody debris jams, side channels and active floodplain wetlands to a channelized river with adjacent pastureland (Amato 1996 cited in WDFW and PNPTT 2000). The loss of forested wetlands has reduced the amount and diversity of habitats and increased the impact of flood flows on the mainstem due to lost floodwater storage capacity (WDFW and PNPTT 2000). Ongoing activities, such as wood removal and bank armoring, continue to impact the floodplain (TAG 2003). Approximately 28 percent of the floodplain has been modified (May 2003). Though much of the lower river floodplain has been modified or developed, a reach lying between the BPA powerlines and the Lazy C is relatively intact with abundant large wood deposits and off-channel habitat (Ted Labbe, personal communication, 2003).

Channel Condition

Fine Sediment

Fine sediment has not been analyzed.

Large Woody Debris

Port Gamble S'Klallam Tribe conducted habitat surveys on a 640m reach at Dosewallips State Park (river mile 0.5) in September-October 2001 and again in April 2002 (before and after an estimated 50 year flood event). This reach was not randomly selected. Rather, it was selected for surveys due to the abundance of wood in various degrees of visibility form the air; consequently the overall wood abundance values (pieces and jams/km) are not representative of the entire river, but characteristics of the wood is informative (Ted Labbe, personal communication, 2003). The alternating alluvial/confined reaches create a mixed pattern of wood deposition as there tends to be less wood in confined reaches (TAG 2003). At present, only the April 2002 data is summarized.

This reach has been highly modified as a result of bank armoring, historical wood cleanouts and other human influences. Most large wood (74 %) occurs in jams of ten or more pieces, and of the 21 jams in this reach, 13 (62%) form pools or are associated with significant bed-scour. Most jams (62%) were small (10 to 20 pieces), and only 14% were large (>50 pieces). Only six key pieces (>9m^3) were mapped in this reach, and of the 917 LW pieces found singly or in jams, 48% were small logs (10cm to 20cm diameter) or rootwads, 43% were medium logs (20cm 50cm), and 8% were large logs (>50cm). Thirty-two percent of single large wood pieces were unstable, 8% were cabled/anchored to a bank, and the balance (60%) included buried, pinned, or root-stabilized pieces. Of those single large wood pieces that could be assigned to a wood type, most (79%) were deciduous (Ted Labbe, unpublished data, 2003). Although historic analysis is still in progress, hardwoods could have historically been a large component (Labbe, draft in review, 2002).

Port Gamble S'Klallam Tribal biologists also surveyed 1,248m of side channel habitat and 1145 m of tributary habitat for large wood. In side-channels, wood abundance ranged from 110.9-285.2 pieces/km with 30% of the 258 inventoried pieces occurring in jams. In the one tributary surveyed, wood abundance measured 97.8 pieces/km with only 9% of the 112 inventoried pieces occurring in jams (Ted Labbe, unpublished data, 2003).

Removal of large woody debris from the river continues to decrease habitat diversity in the lower reach, particularly around the residential developments at Lazy C and Brinnon

(Ted Labbe, cited in WDFW and PNPTT 2000). Loss of the riparian/floodplain forest, primarily conifers, has decreased the future large woody debris recruitment potential. Most of the existing logjams are small and thus do not significantly influence complexity. However, many new large jams formed during a January 2002. Based on changes observed in recent years, the river appears to be on a natural trajectory of natural recovery as new large wood is recruited to the river (from relatively healthy upstream riparian reaches) and the river redistributes this wood into habitat-forming logjams (Ted Labbe, personal communication 2003). The USFS has determined that the lower Dosewallips River has the potential to produce large trees, and subsequent large woody debris, in the future (USFS 1999).

Percent Pool

Pool surveys have not been completed on the mainstem Dosewallips. However, Port Gamble S'Klallam Tribe conducted habitat surveys for pools and large wood on 1,248m in side channels and 1,145m in tributaries in this segment during July and August, 2001. Data collected did not assess percent pool. The TAG, however, collectively agreed that this reach is predominantly riffle habitat with only a few deep pools.

Pool Frequency

Pool frequency ranged between 16.4-74.6 per kilometer or 0.1 to 2.04 channel widths per pool in side channels. Pool frequency was 25.6 per kilometer or 0.18 channel widths per pool in the one tributary surveyed (Ted Labbe, unpublished data, 2003). Pool frequency for the mainstem will be analyzed by summer, 2003 (Ted Labbe, personal communication, 2003) and will remain a data gap until then.

Pool Quality

Average mean residual pool depth in the side channels ranged between 0.17-1.04m. Residual pool depth in the tributary was 0.28m (Ted Labbe, unpublished data, 2003). Where pools associated with bedrock outcroppings and new logjams in the mainstem, they have enough depth to warrant a fair rating (TAG 2003).

Streambank Stability

A splash dam was constructed at approximately river mile 3.2 in 1917 and was in operation for nine to ten years. When water was released, most logs that had accumulated behind the dam were flushed all the way to Hood Canal. The erosive power from this activity was likely catastrophic for salmon habitat in the lower river (WDFW and PNPTT 2000). Diking and riprap, which can often mask unstable streambanks are present in the lower mile and in the vicinity of the housing development at river mile 2.0.

Sediment Input

Sediment Supply

Due to the scouring action of splash dam operation, removal of large woody debris, dike construction and riprap, sediment supply for spawning gravels has likely been reduced (WDFW and PNPTT 2000). There are large deposits of gravels in some places, yet the channel is incising in others. Armoring prevents input of sediment from erosion and there is a lack of wood to stabilize the gravel that is there.

While sediment recruitment from the terrace is reduced, road failures along privately held logging roads, particularly in the vicinity of Mount Jupiter, increase gravel deposits but those deposits are not always reaching the river. As these slopes fail, primarily due to lack of road maintenance, a large amount of sediment deposits at the toe of the slope. This sediment is not reaching the mainstem where it is needed. In one particular case, the channel has become disconnected with the habitat as it flows subsurface beneath this sediment deposit, creating an unstable channel that has moved its mouth. The transport of sediment is therefore disrupted which exacerbates the incision problem in the mainstem. (TAG 2003).

Mass Wasting

Historically, intensive timber harvest and fires have impacted the slopes of the middle and lower watershed. Logging in the watershed began in 1859 and has continued to the present (WDFW and PNPTT 2000). Aerial flight video analysis indicated seven mass wasting events in the lower watershed, four being deep seated and three being shallow rapid events. Of the seven, six were natural and one was road related (USFS 1999). It is not clear if the sediments from these events reached the Dosewallips or any of its tributaries.

Road Density

Road density in the lower watershed is 2.4 miles of road per square mile of watershed (USFS 1999).

Riparian Zones

Riparian Condition

Nearly twenty percent of the riparian zone (by area) has been negatively impacted by land use activities, particularly in the lower mile and in the vicinity of a residential development at approximately river mile 2.0. A riparian forest assessment of the lower 8.7 miles of the mainstem reports 51 percent of the riparian zone has a stand diameter of less than 12 inches, 45 percent between 12 and 20 inches, and no large trees with a diameter greater than 20 inches. Four percent has no riparian buffer. Riparian composition is predominantly mixed forest (52 %) with three percent conifer, 41 percent deciduous and four percent shrubs and grasses (USFS 1999). Although historic analysis is still in progress, hardwoods could have historically been a large component of the riparian zone (Labbe, draft in review, 2002). Buffer widths varied with 58 percent exceeding 132 feet, 21 percent between 66 and 132 feet, and 21 percent less than 66 feet (WDFW and PNPTT 2000).

Water Quality

Temperature
Port Gamble S'Klallam Tribe collected water temperature data at the Dosewallips State Park during 2001 and 2002 with results as follows (Labbe et al. 2002; Ted Labbe, unpublished data 2003):

Table 3. Lower Dosewallips Water Temperature. Data provided by Ted Labbe, PGST.

Stream/Location	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C	2002 AIMT °C	2002 7-DADMT °C
Dosewallips State Park	16.4	16.2	13.0	15.7	15.0

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT = 21-day average of the daily average temperature.

Dissolved Oxygen
Dissolved oxygen is unknown.

Hydrology
The town of Brinnon has no municipal water system. Since 1956, the City of Port Townsend has maintained a permitted water right to divert 50 cfs for municipal use, but has never exercised their application (USFS 1999).

Flow: Hydrologic Maturity
Although only 14 percent of the entire watershed has been harvested, 80 percent of this segment has experienced forest harvest (WDFW and PNPTT 2000). The USFS determined that 6% of the forest of the entire Dosewallips watershed, excluding Rocky Brook, is less than 20 years of age, 10% between 21 and 80 years, 12% between 81 and 200 years and 72% greater than 200 years old (USFS 1999). However, these percentages apply to the entire watershed rather than to this individual segment. Aerial photo analysis indicated that hydrologic maturity outside of USFS ownership is poor, particularly on the sidewall tributaries, due to extensive harvest (TAG 2003)

Flow: Percent Impervious Surface
The Jefferson County Refugia Study, using Landsat imagery, determined approximately 0.31% of the lower Dosewallips watershed is impervious surface (May 2003).

Biological Processes

Nutrients (Carcasses)
According to 2003 SaSI, chinook status is critical, summer chum depressed, fall chum healthy, coho unknown, pink salmon depressed, summer steelhead unknown and winter steelhead depressed. Given the number of critical and depressed stocks, marine-derived nutrient values are likely low compared with historic levels.

Estuaries

The Dosewallips tributary delta historically occupied 444.6 (approximately 1.8 km^2 or 0.7 mi^2) with a perimeter of 6.2 miles or 9.9 km (WDFW and PNPTT 2000). North of the river mouth numerous tidal sloughs, including the fish-bearing Wolcott Slough, drain a large estuarine marsh. At least six diked areas, totaling 68.5 acres, now occupy 15.4 percent of the original summer chum rearing and migration habitat in the estuary. Four tidegates appear to prevent tidal inundation into these diked areas. Ten road causeways totaling 1.2 miles bisect the delta, the largest of which is US 101. Construction of the highway, and the subsequent development, disconnected most of the secondary tidal channels across the delta, including two major distributary channels that were likely linked to the river higher in the delta. Five fill areas associated with residential and agriculture activities occupy 2.5 acres or 0.6 percent of the historic delta (WDFW and PNPTT 2000).

Data Needs

- Evaluate fine sediments
- Collect mainstem channel condition data

Dosewallips River – Rocky Brook Creek to the falls at river mile 12.5

The upper portion of this segment (upstream of river mile 6.1) lies within the Olympic National Forest (Williams et al. 1975). Chinook, steelhead, coho and pinks extend their migration throughout this reach. Chum salmon are limited to river mile 11.5 (TAG 2003). A natural falls restricts anadromous fish migration to the lower 12.5 miles.

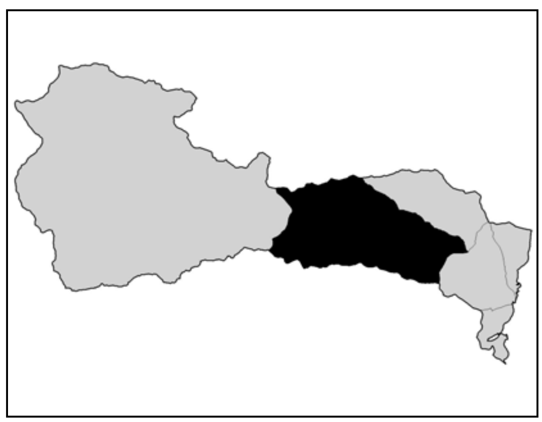

Figure 30. Dosewallips Watershed, RM 3.6 to 12.5. Map provided by Jennifer Cutler, NWIFC

Access and Passage

Artificial Barriers

Two culverts on tributaries along the Jefferson County road adjacent to the mainstem are culverts with unknown passage status. Other barriers to migration, such as gradient, cascades or falls, on numerous tributaries are due to the geomorphic configuration of steep sidewalls.

Floodplains

Floodplain Connectivity

Access to side channels and floodplain wetlands has been eliminated in this reach due to rural residential development and agriculture activities. Wetlands have been drained and the river has been moved against the southern wall and channelized in the vicinity of river mile 5.0 (Randy Johnson, personal communication, 2003). Diking limits flooding access to the floodplain and riprap protects the dikes and unstable banks in the lower part of this segment (WDFW and PNPTT 2000). A major side channel at about river mile 5.0 has been disconnected from the river. It is at least one mile long and historically carried about one-third of the river's flow (Ted Labbe, personal communication, 2003).

Loss of Floodplain Habitat

Approximately 16 percent of the floodplain associated with this segment has been modified (May 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Port Gamble S'Klallam Tribe conducted habitat surveys on a 770m reach at Steelhead Campground (river mile 10.0) in September-October 2001 and again in April 2002 (before and after an estimated 50 year flood event). This reach was selected for surveys due to the abundance of wood in various degrees of visibility from the air; consequently the overall wood abundance values (pieces and jams/km) are not representative of the entire river, but characteristics of the wood are informative. At present, only the April 2002 data is summarized.

This reference reach represents a portion of the river that has experienced less human influence as compared to downstream areas. However, some bank armoring is found on the left bank associated with the campground, and the reach lies immediately downstream of a recent USFS road washout. Similar to the downstream reach, most large wood (78%) occurs in jams, and of the 20 jams in this reach, 15 (75%) form pools or are associated with significant bed scour. Most jams (50%) are small (10-20 pieces), 20% are medium-sized (20-50 pieces), and 30% were large-sized (>50 pieces). Only seven "key pieces" (>9m^3) were mapped in this reach, and of the 1048 large wood pieces found singly or in jams, 38% were small logs (10-20cm diameter) or rootwads, 54% were medium logs (20-50cm diameter) and only 8% were large logs (>50cm). Thirty-nine percent of the single large wood pieces were unstable, only 1% were cabled and/or anchored to a bank, and the balance (60%) included buried, pinned or root-stabilized pieces. Of those single large wood pieces that could be assigned to a wood type, most (64%) were deciduous (Ted Labbe, unpublished data, 2003). Although historic analysis is still in progress, hardwoods could have historically been a large component of the riparian zone (Labbe, draft in review, 2002). A county/forest service road parallels the mainstem along the left bank throughout this segment and limits large wood recruitment. The overall large woody debris condition remains poor, although new logjams have formed upstream of river mile 6.0 after the study took place (Ted Labbe, personal communication, 2003).

In general, the characteristics of large wood and its influence on the river channel were similar in the two reaches though some small differences were observed. Most large wood pieces occur in jams of ten or more pieces, and most jams are associated with pools or significant bed scour. Some (30%) of all jams were classed as large in the upstream reach vs. only 14% in the downstream reach. In the lower river at Dosewallips State Park, nearly half of the jams (48%) were cabled or anchored to a bank with most remaining jams representing small bar top jams with little influence on channel morphology. In the upper reach, most jams were bar apex jams that were found at the head of islands and/or large bars. These jams significantly increase channel complexity. Key pieces are scarce in both reaches and generally occur in jams; most are cottonwood logs. In both reaches, 92% of all pieces were <50cm in diameter, reflecting the small size of most in-channel wood. Approximately one-third of all single pieces were classed as unstable, and in both reaches logs of deciduous wood type predominated (Ted Labbe, unpublished data, 2003).

Port Gamble S'Klallam Tribal biologists also surveyed 916m of side channels and 1634m of tributaries within this segment for large woody debris during July and August, 2001. In the side channels, wood abundance measured 107.1-193.8 pieces/km with 10% of the 151 inventoried pieces occurring in jams. In tributaries, wood abundance was 135.9-370.5 pieces/km, 37% of the 460 pieces occurring in jams (Ted Labbe, unpublished data, 2003).

Percent Pool

Port Gamble S'Klallam Tribe surveyed 916m of side channel habitat and 1634m of tributary habitat within this segment to collect pool data. Most pools were free-formed in side channels and boulder formed in tributaries. As a whole, most side channel and tributary pools were formed by large wood or behind boulders, whereas in the mainstem, wood-formed pools, where they occurred, were generally formed around jams (Ted Labbe, unpublished data 2003). The data did not reflect pool/riffle ratios so percent pool cannot be analyzed from this data.

Pool Frequency

Pool frequency ranged between 40.4-76.9/km or 0.05 to 0.14channel widths per pool in side channels. Pool frequency ranged between 0.02 to 0.19 channel widths per pool and 40.3-98.9/km in tributaries (Ted Labbe, unpublished data, 2003).

Pool Quality

Mean residual pool depth in side channels ranged from 0.28m to 0.56m. Mean residual pool depth in tributaries ranged from 0.23 to 0.5m (Ted Labbe, unpublished data, 2003).

Streambank Stability
Diking and riprap, which can often mask unstable streambanks, are present in the lower half of this segment. One negative aspect of bank protection activities is the reduced supply of spawning gravels in the mainstem.

Sediment Input

Sediment Supply
Logging road failures due to lack of road maintenance continue to be a problem on private holdings in the lower portion of this segment. Along the south wall, the sediment moves directly into the river and eventually downstream. There is more sediment storage long the north wall. A county/forest service road parallels the mainstem along the left bank throughout this segment. In certain dynamic situations where the hill slope meets the floodplain, there are bound to be road failure and erosional problems, as in the recent road failure at approximately river mile 10.8 (TAG 2003).

Mass Wasting
A total of 50 mass wasting events has been documented by the USFS, 48 of which are considered natural, one is road related and one is mining related. Of these, five were deep seated, forty-one were shallow rapid events and four were streambank failures (USFS 1999).

Road Density
Road density is 0.8 miles of road per square mile of watershed (May 2003). A county/forest service road parallels the mainstem along the left bank throughout this segment.

Riparian Zones

Riparian Condition
Nearly twenty percent of the riparian zone (by area) has been negatively impacted by land use activities. A riparian forest assessment of the lower 8.7 miles of the mainstem reports 51 percent of the riparian zone had a stand diameter of less than 12 inches, 45 percent between 12 and 20 inches, and no large trees with a diameter greater than 20 inches. Four percent had no riparian buffer. Riparian composition was predominantly mixed forest (52 %) with three percent conifer, 41 percent deciduous and four percent shrubs and grasses (WDFW and PNPTT 2000). Although the historical analysis is not yet completed, hardwoods could have been a major component of the floodplain historically (Ted Labbe, draft in review, 2002). Buffer widths varied with 58 percent exceeding 132 feet, 21 percent between 66 and 132 feet, and 21 percent less than 66 feet (WDFW and PNPTT 2000). These data can be applied to the lower 5.1 miles of this segment. Large woody debris recruitment in the lower part of this segment is low due to the high percentage of small trees or lack of riparian vegetation.

The US Forest Service ownership begins at river mile 6.1 and extends to river mile 14.0. They have initiated a riparian reserve program along the river corridor using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Mark McHenry, personal communication, 2002). Large woody debris recruitment potential in the upper part of this segment is higher due to the US Forest Service management.

Water Quality

Temperature

Port Gamble S'Klallam Tribe monitored water temperatures near the 6-mile bridge in 2001 and 2002 (Labbe et al. 2002; Ted Labbe, unpublished data, 2003).

Table 4. Middle Dosewallips Water Temperature. Data provided by Ted Labbe, PGST.

Stream/Location	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C	2002 AIMT °C	2002 7-DADMT °C
Mid Dosewallips	14.5	14.2	11.8	13.9	13.2

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT = 21-day average of the daily average temperature.

Dissolved Oxygen
This parameter is a data gap.

Hydrology

Flow: Hydrologic Maturity
The USFS determined that 6% of the forest of the entire Dosewallips watershed, excluding Rocky Brook, is less than 20 years of age, 10% between 21 and 80 years, 12% between 81 and 200 years and 7% greater than 200 years old (USFS 1999). However, these percentages apply to the entire watershed rather than to this individual segment. Therefore, this parameter is a data gap for this segment.

Flow: Percent Impervious Surface
Impervious surface is negligible in this reach (May 2003).

Biological Processes

Nutrients (Carcasses)
According to 2003 SaSI, chinook status is critical, summer chum depressed, fall chum healthy, coho unknown, pink salmon depressed, summer steelhead unknown and winter

steelhead depressed. Given the number of critical and depressed stocks, marine-derived nutrients are likely low compared with historic levels.

Dosewallips River – above the falls

The upper mainstem above the falls is of steep gradient with the steep sidewalls of a confined transport reach. The boundary between the Olympic National Forest and the Olympic National Park is at river mile 14.0. Habitat within the Olympic National Park is assumed to be natural due to their management strategy. Its relatively pristine state likely serves to buffer the lower river from land use runoff changes (Ted Labbe, personal communication, 2003). Impacts typically include non-motorized trails, trailheads and wilderness campsites. Average annual rainfall is between 84.5 and 97.7 inches (May 2003).

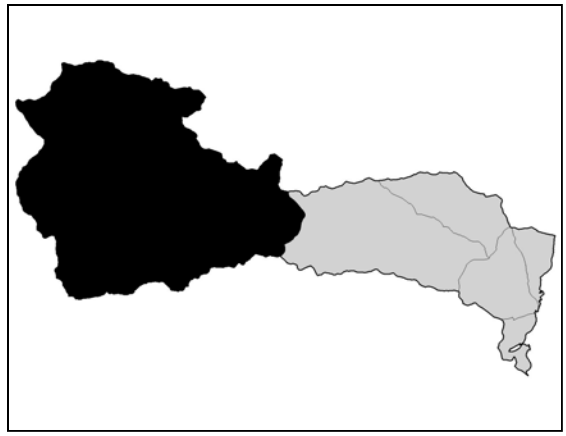

Figure 31. Dosewallips Watershed, Above RM 12.5. Map provided by Jennifer Cutler, NWIFC.

The USPS has conducted surveys in some tributaries of the upper Dosewallips watershed and has found no evidence of native fish presence. Native trout, sculpin and stickleback have not been observed (Sam Brenkman, personal communication, 2003).

Access and Passage

Artificial Barriers

There are no known artificial barrier in this segment.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

Where the gradient flattens out, the floodplain functions naturally. In instances where campgrounds are within the floodplain, as with the campground at Dosewallips Road's end, the impact is negligible in the context of the entire segment (TAG 2003).

Channel Condition

Fine Sediment/Large Woody Debris/Pool Quantity and Quality/Streambank Stability

Due to management strategies within the Olympic National Park, channel conditions are assumed to be in their natural condition.

Sediment Input

Sediment Supply

It is assumed that the sediment supply does not exceed or fall below natural rates.

Mass Wasting

The USFS identified 26 mass wasting events in the upper Dosewallips watershed. Of the 26, 25 were natural events and one was road related. One was deep seated, 24 were shallow rapid events and one was streambank failure (USFS 1999).

Road Density

Roads are minimal within the Olympic National Park.

Riparian Zones

Riparian Condition

The US Forest Service ownership extends to river mile 14.0. They have initiated a riparian reserve program along the river corridor using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002). Riparian condition within the Olympic National Park is considered natural due to their protective management strategy. Large woody debris recruitment in this segment is high due to the US Forest Service and US Park Service management.

Water Quality

Temperature

This parameter is a data gap.

Dissolved Oxygen

This parameter is a data gap.

Hydrology

Flow: Hydrologic Maturity

Due to management strategies within the Olympic National Park, it is assumed that flows are within a natural range.

Flow: Percent Impervious Surface

A few trails, trailheads and wilderness campsites create very little impact within Olympic National Park boundaries.

Biological Processes

Nutrients (Carcasses)
This parameter is a data gap. The USPS has been conducting fish presence surveys in the upper watershed. The fish they are finding appear to be introduced species, i.e. brook trout and rainbow trout. Native fish, such as native rainbow, bull trout, cutthroat, and sculpin are lacking (Sam Brenkman, personal communication, 2003). Population density of the existing introduced fish has not been determined.

Rocky Brook

Rocky Brook, a steep gradient, left bank tributary to the Dosewallips, has an impassable falls at approximately river mile 0.3. It is the largest tributary, approximately 5,672 acres (USFS 1999) with chinook, chum, pinks, steelhead, coho and cutthroat utilizing spawning and rearing habitat between the confluence and the falls. Average annual rainfall is 68.3 inches (May 2003).

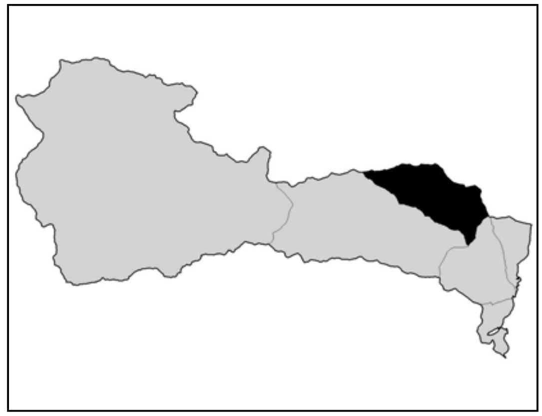

Figure 32. Rocky Brook Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

Between the mouth and the falls at river mile 0.3, there are no migration barriers. A diversion dam is at approximately river mile 0.5 which prohibits resident fish migration. A fair number of culverts block resident migration upstream (Marc McHenry, personal communication, 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
This parameter is not applicable due to gradient.

Channel Condition

Fine Sediment
Fine sediments have not been analyzed in this reach.

Large Woody Debris
US Forest Service surveys in 1990 identified 0.02 pieces/m in the lower half mile of the stream (Phil DeCillis, personal communication, cited in WDFW and PNPTT 2000). Large woody debris recruitment is poor due to the extensive logging in the watershed (USFS 1999).

Percent Pool

US Forest Service surveys in 1990 identified 23 percent of the habitat area in pools (Phil DeCillis, personal communication, cited in WDFW and PNPTT 2000). Recent surveys by Port Gamble S'Klallam Tribe quantified pools in terms of median pool area which was 32.2 square meters within a survey length of 672 meters and mean bankfull width of 12.6 (Ted Labbe, unpublished data, 2003).

Pool Frequency

Pool frequency is 0.18 (Ted Labbe, unpublished data, 2003).

Pool Quality

Mean residual pool depth is 0.5 meters (Ted Labbe, unpublished data, 2003).

Streambank Stability

This parameter is a data gap.

Sediment Input

Sediment Supply

Sediment supply is unknown although the lower 0.2 miles of Rocky Brook contains excellent spawning gravels (TAG 2003).

Mass Wasting

Between 1920 and 1990, 65 percent of Rocky Brook sub-watershed was clearcut. Forty five mass wasting events have occurred in the Rocky Brook watershed. Of those, 23 were shallow rapid events and 22 were surface erosion. Of the 45, 3 were natural, 36 were road-related and 6 were harvest related (USFS 1999).

Road Density

Road density is 3.7 miles of road per square mile of habitat (USFS 1999).

Riparian Zones

Riparian Condition

Riparian composition throughout the watershed is 60% conifer and 40% mixed forest (USFS 1999). Buffer width is unknown. The upper watershed that is within USFS boundaries falls under the federal forest plan. The USFS has initiated a riparian reserve program along the stream corridor using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Mark McHenry, personal communication, 2002).

Water Quality

Washington Department of Ecology collected water quality data in Rocky Brook on September 12, 2000 as a baseline: pH = 7.7; alkalinity (Gran ANC mg/L) = 33.6; conductivity = 73.75 uS at 25^{o}C; calcium = 9 mg/L; magnesium = 2.9 mg/L; Sodium =

1.8 mg/L; potassium = 0.1 mg/L; ammonium-nitrogen = 0 mg N/L; chloride = 0.5 mg/L; nitrate-nitrogen = 0.9 mg N/L; sulfate = 2.4 mg/L; total suspended solids = -1.2 mg/L; total phosphorus = 2 ug/L; total nitrogen = 0.09 mg/L; turbidity = 0.05 NTU.

Temperature

Port Gamble S'Klallam Tribe monitored water temperature in 2001 (Labbe et al. 2002) and 2002 (Ted Labbe, unpublished data 2003) with the following results:

Table 5. Rocky Brook Water Temperature. Data provided by Ted Labbe, PGST

Stream/Location	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C	2002 7-DADMT °C	2002 21-DADT °C
Rocky Brook, Near the mouth	17.4	17.0	14.5	16.5	16.1

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT = 21-day average of the daily average temperature.

Dissolved Oxygen

This parameter is a data gap.

Hydrology

Flow: Hydrologic Maturity

Rocky Brook watershed has 487 acres (9%) in forests younger than 20 years of age, 3,268 acres (59%) in forests between the age of 21 and 80 years, 86 acres (2%) in forests between the age of 80 and 200 years and 1,735 acres (31%) in forests over 200 years old (USFS 1999).

Flow: Percent Impervious Surface

Impervious surface is negligible in Rocky Brook (May 2003).

Biological Processes

Nutrients (Carcasses)

The lower 0.3 miles of Rocky Brook provides good spawning habitat. The upper watershed is restricted to resident fish. Escapement and nutrient values are unknown.

Data Needs

- Determine streambank stability
- Assess fine sediments

Action Recommendations (sequenced)

- Protect and restore estuary function

NOTE: Acquisition or conservation easements may be needed to accomplish the following restoration activities:

a. Assess/restore constriction at Highway 101 causeway
b. Restore tidal process
c. Reconnect tidal channels/wetlands

- Protect high quality habitat through acquisition or conservation easement
  a. Target properties in lower floodplain and channel migration zone (lower 3.0 miles), particularly the reach between the Lazy C and the powerlines
  b. Target estuary properties
- Restore natural riverine function
  NOTE: Acquisition or conservation easements may be needed to accomplish the following restoration activities:
  a. Restore sinuosity and complexity (LWD) in channelized reaches
  b. Add LWD between river mile 2.0 and mouth
  c. Identify/abate sediment sources, i.e. USFS roads
  d. Plant riparian zone
  e. Evaluate passage/road crossings

Walker Creek

Walker Creek, also known as James Creek and approximately 1.75 miles in length (Williams et al. 1975), is associated with a watershed of approximately 1,485 acres (May 2003). Gradient is 2-4% in the lower 0.5 mile, increasing to 4-6% between river mile 0.5 to 0.75 and becoming more moderate at 1-2% from river mile 0.75 to the headwaters at river mile 1.75 (Jeff Davis, personal communication, 2003). Average annual rainfall is approximately 53 inches (May 2003).

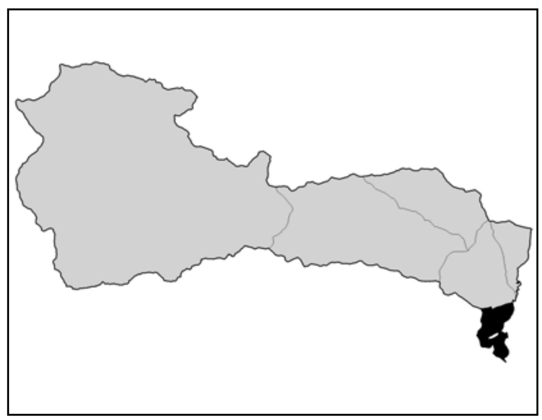

Figure 33. Walker Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers to fish migration on Walker Creek below the two 8-10 foot cascades that fall between river mile 0.75 and the headwaters. An old instream concrete water diversion structure between river mile 0.5 and 0.75 has filled with gravel and appears to be passable to fish. Three crossings in the upper section present some passage problems. The downstream road crossing has two 24-inch round pipes that are perched by 2 feet and are set at a 4-6% gradient which bock fish migration. The road fill is eroding into the stream channel and debris is blocking the inlet of both culverts. Adult trout have been observed below the culverts. The middle road crossing is a 6-foot culvert under a dead-end road that appears to have been used for a logging landing. This culvert is not a barrier but it is devoid of streambed material within the culvert. The upper road crossing consists of two 24-inch culverts set at a 2% gradient. Both culverts appear to be passable during normal flows but are likely barriers during high flows. The road fill is eroding into the stream channel (Jeff Davis, unpublished data, 2003). The two residential road crossings appear to have been constructed without appropriate permits and should be replaced with appropriately designed crossing to support the existing resident trout population (Jeff Davis, personal communication, 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

These parameters are not applicable due to gradient.

Channel Condition

Fine Sediment

Fine sediments are a data gap.

Large Woody Debris

Large wood falls into the fair category in the lower 0.5 miles, good in the next 0.25 miles and poor in the upper mile (Jeff Davis, personal communication, 2003). Approximately 90% of the large wood in the lower 0.5 miles of the stream is less than 24 inches in diameter and consists mostly of deciduous trees. Between river mile 0.5 and 0.75, approximately 30% is greater than 24-inch diameter decaying conifer wood and 70% less than 24-inch diameter deciduous. This part of the channel is braided due to woody debris jams. Very little wood is present within the channel in the upper watershed and recruitment is poor due to riparian harvest approximately 15 years ago (Jeff Davis, unpublished data, 2003).

Percent Pool

Pool to riffle ratio appears to be 1:2.5 in the lower 0.5 miles and becomes 1:1.5 in the next 0.25 miles (Jeff Davis, unpublished data, 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

Average pool depth in the lower 0.5 miles appears to be 1-2 feet (Jeff Davis, unpublished data, 2003).

Streambank Stability

Streambank stability is unknown.

Sediment Input

Sediment Supply

Approximately 50% of the substrate is 12-16-inch rock, 30% is 2-6-inch cobble and 20% <1-2-inch gravel in the lower 0.5 mile. Between river mile 0.5 and 0.75 the substrate is largely 6-15-inch cobble/boulder with patches of exposed glacial till within the channel which appear to be erodible. The upper mile presents good spawning habitat for resident fish with the substrate consisting of 40% 4-6-inch cobble and 60% 2-inch minus gravel (Jeff Davis, unpublished data, 2003).

Mass Wasting

The Dosewallips Watershed Analysis (USFS 1999) combines Turner Creek and Walker Creek in their evaluation of mass wasting potential, rating them high in susceptibility to shallow mass wasting events. Quantification of mass wasting events has not occurred. Visual observations of the plant community indicate evidence of mass wasting between river mile 0.5 and 0.75 in the past 10 years (Jeff Davis, personal communication, 2003).

Road Density

Road density in Walker Creek is 8.7 miles of road per square mile of watershed (May 2003).

Riparian Zones

Riparian Condition

Riparian overstory in the lower 0.5 mile contains approximately 50% mature red alder, 40% mature western red cedar and western hemlock, and 10% second growth western red cedar. The understory consists of sword fern, Indian plum and vine maple. Between river mile 0.5 and 0.75, the riparian zone is approximately 100-feet wide and is mostly second growth deciduous and conifer trees. The area outside of the ravine was clearcut approximately 10-25 years ago. Large woody debris recruitment in this section is low. The riparian zone in the upper mile was completely harvested approximately 15 years ago (Jeff Davis, unpublished data, 2003).

Water Quality

Temperature/Dissolved Oxygen

These parameters are data gaps.

Hydrology

Flow: Hydrologic Maturity

Turner and Walker creeks combined have approximately 105 acres (7%) in forests under 20 years of age, 1,303 acres (88%) in forests between the age of 21 and 80, 56 acres (4%) in forests between 80 and 200 years old, and only 13 acres (1%) in forests older than 200 years (USFS 1999). However, close examination of 2001 aerial photos indicates hydrologic maturity to be poor in Walker Creek (TAG 2003).

Flow: Percent Impervious Surface
Approximately 1.9% of Walker Creek watershed is impervious surface (May 2003).

Biological Processes

Nutrients (Carcasses)
Escapement in Walker Creek is unknown. However, numerous juvenile coho have been observed in off-channel, isolated pools. Adult cutthroat have been observed to the uppermost road crossing.

Data Needs
- Collect channel condition data
- Determine riparian condition
- Collect water quality data

Action Recommendations
- Provide fish passage
- Decommission roads where applicable

DUCKABUSH SUB-BASIN

The Duckabush sub-basin, located in the southwest corner of Jefferson County, borders the Dosewallips watershed to the north and the Hamma Hamma watershed to the south. It consists of the Duckabush River (WRIA 16.0351) and its tributaries for a total of approximately 119 river miles (Williams et al. 1975). The Duckabush sub-basin has been divided into three segments to assess habitat limiting factors:

- Duckabush River, mouth to river mile 5.0
- Duckabush River, river mile 5.0 to the falls at river mile 8.0
- Duckabush River, upstream of the falls

Duckabush River

The Duckabush River originates in the Mount Duckabush/Mount Steele vicinity of the Olympic Mountains and flows generally eastward into Hood Canal approximately 4 miles south of the town of Brinnon. The valley walls are steep throughout all but the lower two miles of the river (Williams et al. 1975). Sandstone, siltstone and slate bedrock formations dominate the headwaters while the lower two-thirds of the watershed is within the basalt-rich Crescent formation. Limited alluvial deposits are found along the lower 6 miles (WDFW and PNPTT 2000). The watershed covers an area of approximately 49, 933 acres or 75 square miles (USFS 1998)

The entire Duckabush mainstem is approximately 24.5 miles in length with over 50 tributaries contributing an additional 94.3 stream miles (Williams et al. 1975). Average annual discharge is 411 cfs with a range or 46 to 9,240 for the years 1939-1996. The gaging station is at river mile 4.9 (WDFW and PNPTT 2000). There are two annual runoff peaks, one occurring in November through February as a result of winter rains and the other associated with spring snowmelt during May and June (USFS 1998). The upper 75% of the watershed is protected within Olympic National Park boundaries and the USFS Brothers Wilderness.

Table 6. Land Ownership and Land Use Allocation in the Duckabush Watershed (USFS 1998).

Ownership	Reserved	Wilderness	Late-Successional Reserve	Adaptive Management	Riparian Reserve	Acres
USPS	28,859					28,859
OSFS		8,057	7,328	163		15,549
Private Forest						4,443
State						1,082
Totals	28,859	8,057	7,328	163		49,933

The major disturbance regimes are fire, wind, snow avalanche and human activity, particularly timber harvest. In the riparian zone, flooding has been and continues to be an important disturbance. Mass wasting usually affects a small part of the watershed at any one time, but is slow to heal and susceptible to exotic plant invasion. Fire, occurring at approximately 200-year intervals, is the natural disturbance that has affected the largest area (USFS 1998). Timber harvest is the dominant land use in the lower watershed, both on National Forest lands and private lands, which began in the early 1900s. WDF Stream Improvement Division removed logjams and blasted impassable falls between 1955 and 1970 to improve fish passage (WDFW and PNPTT 2000). The lower river fluctuates in width, which appears to expand in association with large riparian disturbance such as fire and railroad logging (USFS 1998).

US Forest Service watershed analysis provided mass wasting, riparian condition and hydrologic maturity data. Hood Canal Salmon Enhancement Group collected large woody debris and fine sediment data on the lower 8 miles of the river. Point No Point Treaty Council calculated road densities. Jefferson County quantified percent impervious surface from Landsat imagery. The TAG provided additional experience and best professional knowledge of the watershed.

Duckabush River, mouth to river mile 5.0

USFS ownership begins at approximately river mile 2.3 and extends upstream to approximately river mile 11.5. Between the USFS lands and the mouth of the river, land use is predominantly managed for timber harvest with some rural residential and urban commercial development in the lower 1.5 miles. The river valley walls are generally steep throughout, with a broad floodplain only in this lower section. The few tributaries to this segment are small and steep, with a small amount of spawning and rearing habitat in their lower reaches. Although most are not fish-bearing due to steep gradients, the management of these drainages can affect fish habitat in the floodplain (May 2003). Chinook, coho, chum (including summer chum), pinks, steelhead and searun cutthroat utilize the entire segment (TAG 2002).

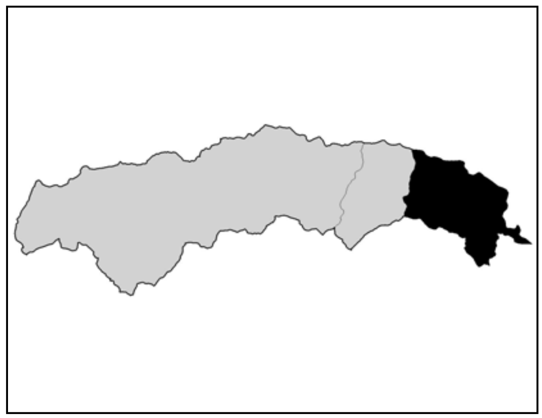

Figure 34. Duckabush Watershed, RM 0.0 to 5.0. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no artificial barriers along the mainstem and fish have access throughout this segment. Most tributary barriers are natural in the form of cascades and falls. There two culvert barriers on the first right bank tributary but they might be upstream of a cascade barrier (Till et al. 2000). There are at least two partial barrier culverts on the first left bank tributary to the Duckabush (Steve Todd, personal communication, 2003). There is another road crossing problem on an unmapped left bank tributary that passes beneath

Coyote Lane, just inside the Olympic National Forest boundary. The crossing is an old log structure topped with fill and with the creek seeping through the bottom of the wood structure. There is very little habitat above this crossing, but when the road crossing eventually fails, it will deliver a substantial amount of road fill material to the river mainstem (Ted Labbe, personal communication, 2003). Additional fish passage problems with culverts on logging roads are unknown.

Floodplains

Floodplain Connectivity

There are two left bank side channels upstream from the BPA powerlines. Both have connections with the mainstem at their upper and lower ends and are used heavily by spawning chum salmon. Log jams positioned at the head end of these side channels regulate flows through them. The mainstem has broken through the head end of one of these side channels recently and subsequently the side channel may become the primary channel (Marty Ereth, personal communication, 2003). Armored streambanks in the lower watershed restricts flood. Floodplain connectivity rates fair overall but poor in the lower reach (TAG 2003).

Loss of Floodplain Habitat

Both the removal of large woody debris from the channel and rural residential development within the floodplain have confined the river to a single channel with reduced channel complexity. Nearly 25% of the riparian zone (by area) below river mile 3.0 is now developed with urban/commercial (12%), rural residences (9%), and roads/dikes (3%). Recreational homesite development has occurred along the lower 1.5 miles of floodplain (WDFW and PNPTT 2000).

The Olympic National Forest begins at river mile 2.3 where the riparian reserve program is in place along the floodplain. The channel becomes naturally confined at about river mile 2.5. Overall, floodplain habitat is fair, but poor in the lower half mile (TAG 2003).

Channel Condition

Fine Sediment

Hood Canal Salmon Enhancement Group sampled spawning gravels from the lower Duckabush system during August of 2002 using TFW ambient monitoring methodology with McNeil gravel sampling equipment. Twelve samples were taken from each of three sampling sites in the lower 560 meters of the river. The first location at 1,800-1,900 meters yielded 7.37% fines <0.85mm (standard deviation of 1.58), the second location at 3,500-3,700 meters yielded 7.25% fines <0.85mm (standard deviation of 1.63), and the third location at 5,500-5,650 meters yielded 7.43% fines <0.85mm with a standard deviation of 3.12 (Lee Boad, unpublished data, 2003).

Large Woody Debris

Hood Canal Salmon Enhancement Group surveyed the lower 8,500 meters of the Duckabush system during the summer of 2002. A total of 510 large wood pieces were identified. Of these, 222 were considered part of a logjam. Species breakdown consisted of 226 conifer and 257 deciduous. The diameter class breakdown consisted of 155 in the 10-20 cm range, 288 in the 21-50 cm range, and 67 greater than 50 cm. The decay class consisted of 43 fresh, 332 firm and 126 rotten. The mean large wood piece types were 295 logs, 7 rootwads and 112 log plus rootwads. The stability class consisted of 29 rooted, 31 buried, 305 pinned and 142 unstable. 19 large wood pieces were considered pool forming (Lee Boad, unpublished data, 2003).

Percent Pool
Percent pool between river mile 0.2 and 2.3 is 32% (WDFW and PNPTT 2000).

Pool Frequency/Pool Quality
These parameters are data gaps.

Streambank Stability
Armored banks in the lower watershed could mask streambank instability. Actual streambank condition is unknown.

Sediment Input

Sediment Supply
Sediment supply is unknown.

Mass Wasting
The USFS combined this segment and the following segment for a total of 8.0 river miles in their watershed analysis. They identified 95 slope failures that have occurred in the combined segments since 1939. Of those 31 (33%) were road related, 2 (2%) were associated with logging landings, 3 (3%) resulted from clearcuts, 52 (55%) associated with fire (both natural and human-caused) and 7 (7%) were natural. It is estimated that 74 (78%) delivered sediment to stream channels (USFS).

Road Density
Overall, road density in the watershed is low at 0.6 miles of road per square mile of habitat. However, in the lower Duckabush, road density is 2.2 miles of road per square mile of watershed (WDFW and PNPTT 2000). These roads have contributed significantly to mass wasting events (USFS 1998).

Riparian Zones

Riparian Condition
Nearly 25% of the riparian zone (by area) below river mile 3.0 is now developed with urban/commercial (12%), rural residences (9%), and roads/dikes (3%). Approximately 32% of the riparian zone (the area 200 feet from the stream) consists of small diameter trees (<12 inches) and 66 % is of medium diameter (12-20 inches). There are no large trees greater than 20 inches in diameter and 2% of the riparian zone has no trees. Short

term large woody debris recruitment is negligible. Regarding riparian composition, approximately 5% is conifer, 25% deciduous, 66% mixed forest and 4% grasses. Regarding buffer width, 32% is greater than 132 feet, 18% is between 66 and 132 feet, and 50% is less than 66 feet (WDFW and PNPTT 2000). Although historical analysis is still in progress, hardwoods could have historically contributed significantly to the floodplain and riparian composition (Labbe, draft in review, 2002).

Riparian reserves, which leave two site-potential tree heights on fish bearing streams and one site-potential tree height on non-fish bearing streams with steep and unstable slopes, are in place on USFS land, which begins upstream of river mile 2.3 (USFS 1998).

Water Quality

Temperature

Port Gamble S'Klallam Tribe began their monitoring schedule in the Duckabush at the BPA powerline crossing in 2002 with results as follows (Ted Labbe, unpublished data 2003):

Table 7. Lower Duckabush Water Temperature. Data provided by Ted Labbe, PGST.

Stream/Location	2002 AIMT °C	2002 7-DADMT °C
Lower Duckabush	14.5	14.0

Note: AIMT = annual instantaneous maximum temperature;
7-DADMT = 7-day average of the daily maximum temperature.

Dissolved Oxygen

This parameter is a data gap.

Hydrology

Flow: Hydrologic Maturity

The USFS combined this segment with the upstream segment to analyze hydrologic maturity in the lower 8 miles of watershed. Approximately 7% (742 acres) of the lower watershed is in immature hydrologic maturity (<10% total crown closure and/or <25% conifer), 23% (2,749 acres) is in intermediate hydrologic maturity (10-70% crown closure and >25% conifer) and 69% (7,705 acres) is mature (>70% crown closure and >25% conifer). One percent is unknown (USFS 1998).

Approximately 16% (181 acres) of the lower watershed is less than 30 years old, 67% (7,458 acres) is between 31 and 95 years old, 9% (1,022 acres) is between 96 and 297 years old and 0.3% (37 acres) is older than 297 years (USFS 1998). Close examination of 2001 aerial photos of the lower two miles indicates recent clearcuts in various stages of young growth (TAG 2003).

Flow: Percent Impervious Surface
Approximately 0.26% of the lower watershed is impervious surface (May 2003).

Biological Processes

Nutrients (Carcasses)
Chinook are rated critical, summer chum, pinks and winter steelhead are considered depressed and fall chum and coho are healthy (WDFW, DRAFT IN REVIEW, 2003). Four of the six stocks fall well below escapement goals.

Estuaries
Highway 101 causeways impact the Duckabush estuary, disrupting tidal circulation, and impeding fish access to productive salt marsh and slough habitats (WDFW and PNPTT 2000). Dikes extending seaward of SR101 along both banks of the mainstem severely restrict lateral connectivity with tidal channels and salt marsh habitat. See nearshore discussion for more detail.

Data Needs
- Assess channel conditions (pool quantity and quality, streambank stability)
- Assess fish passage barriers

Duckabush River, river mile 5.0 to falls at river mile 8.0

This segment is entirely within Olympic National Forest boundaries. Salmonids have been observed upstream as far as river mile 6.5.

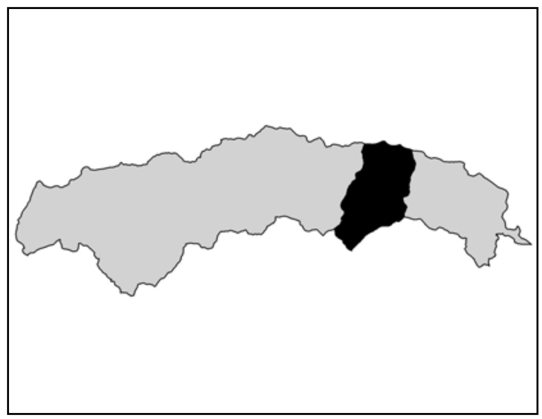

Figure 35. Duckabush Watershed, RM 5.0 to 8.0. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers
There are no artificial barriers on the mainstem. The river valley walls are steep as are their associated tributaries. Natural barriers, such as cascades and falls, limit fish passage although some spawning and rearing habitat is available in some of the lower reaches. A culvert on a small low gradient left bank tributary at the downstream end of Collins campground is a partial barrier. Passage problems due to culverts on logging roads are minimal due to the small number of roads in this segment (TAG 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
The majority of this segment is a confined transport reach. However, there are a few small floodplain habitats worth noting. One is a side channel located immediately upstream of Collins Campground on the left bank of the river. A debris jam at the upper end moderates flow through the channel. There are few pools and the substrate is primarily cobble with little spawning habitat. Some pocket gravels do exist and small resident trout have been observed spawning in this side channel during normal coho spawn timing. The other floodplain habitat is more of a seep on a terrace on the right bank located approximately 200 meters upstream of Collins campground. It is less than 100 meters long (Marty Ereth, personal communication, 2003).

Channel Condition

Fine Sediment
Fine sediment is unknown.

Large Woody Debris
Large woody debris is unknown.

Percent Pool/Pool Frequency/Pool Quality
Pool information has not been quantified.

Streambank Stability
There is a negligible amount of sediment from stream banks (TAG 2003).

Sediment Input

Sediment Supply
Gravels are small and abundant in this reach (Marty Ereth, personal communication, 2003). This parameter is a data gap, although the TAG noted the steep canyon walls within bedrock (TAG 2003).

Mass Wasting
The USFS combined this segment with the lower segment for analysis of mass wasting events as well as a separate analysis of Murhut/Cliff creeks. They identified 95 slope failures that have occurred in the combined mainstem segments since 1939. Of those 31 (33%) were road related, 2 (2%) were associated with logging landings, 3 (3%) resulted from clearcuts, 52 (55%) associated with fire (both natural and human-caused) and 7 (7%) were natural. It is estimated that 74 (78%) delivered sediment to stream channels (USFS 1998).

Murhut/Cliff creeks have experienced numerous mass wasting events resulting from human impacts as well. Out of a total of 38 mass wasting events, 8 (21%) were natural, 1 (3%) was from fire, 6 (16%) resulted from clearcut activities, 2 (5%) were associated with logging landings and 21 (55%) resulted from road failures (USFS 1998).

Road Density

Road density in the middle Duckabush River, including Murhut/Cliff creeks, is 0.8 miles of road per square mile of watershed (USFS 1998).

Riparian Zones

Riparian Condition

This entire segment is within the Olympic National Forest boundaries. Riparian reserves, which leave two site-potential tree heights on fish bearing streams and one site-potential tree height on non-fish bearing streams with steep and unstable slopes, are in place as part of the federal forest plan (Marc McHenry, personal communication, 2002).

Water Quality

Temperature/Dissolved Oxygen

These parameters are data gaps.

Hydrology

Flow: Hydrologic Maturity

The USFS combined this segment with the downstream segment to analyze hydrologic maturity in the lower 8 miles of watershed. Approximately 7% (742 acres) of the combined watershed is in immature hydrologic maturity (<10% total crown closure and/or <25% conifer), 23% (2,749 acres) is in intermediate hydrologic maturity (10-70% crown closure and >25% conifer) and 69% (7,705 acres) is mature (>70% crown closure and >25% conifer). One percent is unknown (USFS 1998).

Approximately 16% (181 acres) of the combined watershed is less than 30 years old, 67% (7,458 acres) is between 31 and 95 years old, 9% (1,022 acres) is between 96 and 297 years old and 0.3% (37 acres) is older than 297 years (USFS 1998).

The USFS analysis extends their middle reach beyond river mile 8 but is included in this discussion with its major tributary, Murhut Creek, which enters the Duckabush at approximately river mile 7. Approximately 19% (4,441 acres) is hydrologically immature (<10% total crown closure and/or <25% conifer), 27% (6,275 acres) is of intermediate maturity (10-70% total crown closure and >25% conifer), and 53% (12,118 acres) is hydrologically mature (USFS 1998).

Approximately 2% (424 acres) of the forest cover in the middle Duckabush/Murhut Creek watershed is less than 30 years old, 10% (2,385 acres) is between 30 and 95 years old, 55% (12,620 acres) is between 96 and 297 years old, and 14% (3,123 acres) is older than 298 years (USFS 1998).

Flow: Percent Impervious Surface

There is negligible impervious surface within this segment of the watershed (May 2003).

Biological Processes

Nutrients (Carcasses)

Chinook are rated critical, summer chum, pinks and winter steelhead are considered depressed and fall chum and coho are healthy (WDFW, DRAFT IN REVIEW, 2003). Four of the six stocks fall well below escapement goals. Known fish distribution is limited to the lower seven miles (Thom Johnson, personal communication, 2003).

Duckabush River, upstream of the falls

Olympic National Park boundary begins at approximately river mile 11.5. Olympic National Forest lies between river mile 11.5 and river mile 2.3. It is relatively pristine and likely serves to buffer the lower river from land use runoff changes (Ted Labbe, personal communication, 2003).

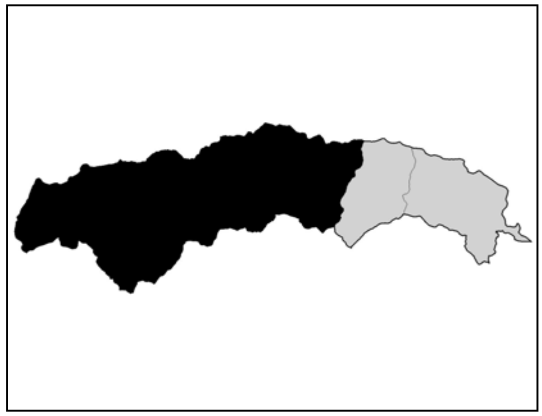

Figure 36. Duckabush Watershed, above RM 8.0. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

Anadromous fish do not have access to this segment due to an impassable falls. The number of roads is negligible above the falls so passage is not an impact to resident fish (TAG 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable due to gradient. It is a confined transport reach.

Channel Condition

Fine Sediment/Large Woody Debris/ Pool Quantity and Quality/Streambank Stability

There are no channel condition data for the upper watershed but the TAG assumes the habitat is in a natural functioning condition due to the management strategy of the Olympic National Forest and the Olympic National Park (TAG 2003).

Sediment Input

Sediment Supply

It is assumed that sediment supply does not exceed natural levels (TAG 2003).

Mass Wasting

The upper watershed, including Cliff Creek, was evaluated for mass wasting events. Of 58 events, 44 (76%) were natural and 14 (24%) were fire (natural) related (USFS 1998).

Road Density

There are no roads within Olympic National Park boundaries and also no roads within the Olympic National Forest in this segment (TAG 2003).

Riparian Zones

Riparian Condition

Riparian condition is assumed natural due to the management strategy of the Olympic National Park (TAG 2003).

Water Quality

Temperature/Dissolved Oxygen

These parameters are data gaps but are assumed in natural condition due to the upper watershed being within Olympic National Park/Forest boundaries (TAG 2003).

Hydrology

Flow: Hydrologic Maturity

Approximately 37% (5,869 acres) of the upper Duckabush watershed (including Crazy Creek and the headwaters) is hydrologically immature (<10% total crown closure and/or <25% conifer), 20% (3,171 acres) is of intermediate maturity, and 53% (6,861 acres) is hydrologically mature (USFS 1998).

There are no stands less than 30 years of age in the upper Duckabush watershed, including Crazy Creek and the headwaters. Approximately 0.4% (70 acres) is between 71 and 95 years old, 39% (6,241 acres) between 146 and 297 years old and 21% (3,333 acres) older than 298 years (USFS 1998).

Flow: Percent Impervious Surface

There is negligible impervious surface in the upper Duckabush watershed (May 2003).

Biological Processes

Nutrients (Carcasses)

Fish abundance in the upper watershed is unknown.

Action Recommendations

NOTE: Acquisition or conservation easements may be needed to accomplish the following restoration activities:

- Protect and restore estuary function

    - Assess/remove constriction at Highway 101 causeway
    - Remove or set back dikes/levees
    - Restore natural tidal distributary channels
- Restore natural riverine function
    - Restore sinuosity/complexity in lower 2.5 miles; assess/address bank armoring impacts
    - Identify/abate sediment sources, i.e. USFS roads
    - Assess/restore riparian zone
    - Assess pool quality and quantity
- Properties in the lower floodplain should be targeted for acquisition or conservation easements from willing sellers

HAMMA HAMMA SUB-BASIN

The Hamma Hamma watershed lies to the south of the Duckabush watershed, east of the Skokomish watershed, and north of the Lilliwaup and Jorsted watersheds (WDFW and PNPTT 2000). The Hamma Hamma sub-basin includes McDonald Creek (WRIA 16.0349), Fulton Creek (WRIA 16.0332), Schaerer Creek (WRIA 16.0326), an unnamed tributary to Hood Canal at Mike's Beach Resort (WRIA 16.0325), Waketickeh Creek (WRIA 16.0318), Hamma Hamma River (WRIA 16.0251), and Johns Creek, a tributary to the Hamma Hamma River (WRIA 16.0253) (Williams et al. 1975). The following reaches were identified by the TAG:

- McDonald Creek, entire watershed
- Fulton Creek, entire watershed
- Schaerer Creek, entire watershed
- Unnamed Tributary at Mike's Beach Resort, entire watershed
- Waketickeh Creek, entire watershed
- Hamma Hamma River, mouth to canyon at river mile 1.5
- Hamma Hamma River, river mile 1.5 to falls at river mile 2.5
- Hamma Hamma River, above the falls
- Johns Creek, entire watershed

McDonald Creek

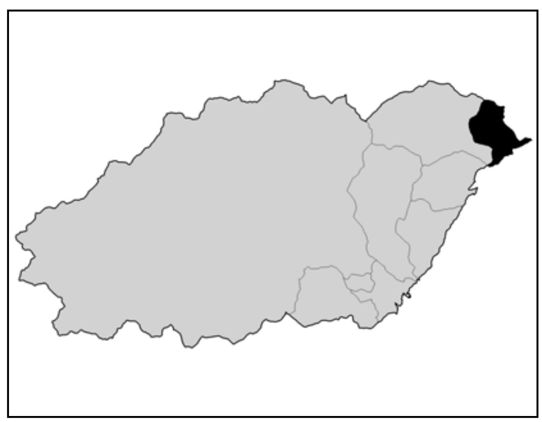

Figure 37. McDonald Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

McDonald Creek is 1.9 miles long with fish access limited to the lower 0.3 to 0.5 miles, immediately upstream of the powerlines, due to impassable cascades, steep gradient, and a logjam that moves around downstream of the west fork (TAG 2003). Coho and chum utilize this lower reach (Williams et al. 1975). Steep concave headwaters drain the hillslopes controlled by bedrock geology followed downstream by a reduced gradient as the stream flows across and into a bench system formed by glacial deposits. A steep confined section follows downstream with steep cascade reaches emptying into a short alluvial fan. Stream density is 2.9 miles per square mile of watershed. There are 12 acres classified as lakes, ponds and wetlands. Out of a total of 1,988 acres within this watershed, only 43 acres are within the Olympic National Forest. Approximately 440 acres of other ownership fall within the National Forest boundaries (USFS 1997).

Access and Passage

Artificial Barriers

There are no known artificial barriers to fish migration on McDonald Creek.

Floodplains

Floodplain Connectivity

With the exception of the lower 100+ meters, floodplain connectivity appears to be intact (TAG 2003).

Loss of Floodplain Habitat

Highway 101 lies within the floodplain and constricts the mouth with associated fill. The lower 100+ meters appears to have been straightened and the southern portion partially filled with two small structures immediately upstream of the road (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment was collected in 1993 by Peter Bahls, Port Gamble S'Klallam Tribe, and Carol Bernthal, Point No Point Treaty Council, in three different river segments. Out of 40 samples in segment 1, 2 rated fair by LFA standards and 38 rated good. In segment 2, 6 samples rated poor, 13 fair and 102 good. In segment 4, 36 samples rated poor, 16 rated fair and 76 rated good (Steve Todd, personal communication, 2003).

Large Woody Debris

Large woody debris data was collected in 1993 by Peter Bahls, Port Gamble S'Klallam Tribe, and Carol Bernthal, Point No Point Treaty Council, in three different river segments. Segment 1 had 0.19 pieces/channel length (m) and 0.67 pieces/channel width (m). Segment 2 had 1.84 pieces/channel width (m) and section 4 had 1.57 pieces/channel width (m) (Steve Todd, personal communication, 2003). Large wood recruitment potential has been evaluated by the USFS. Approximately 62% is poor, 3% fair and 35% good, according to USFS standards (USFS 1997).

Percent Pools

Pool data was collected in 1993 by Peter Bahls, Port Gamble S'Klallam Tribe, and Carol Bernthal, Point No Point Treaty Council, in three different river segments. There were 42% pools in segment 1 (gradient range of 2-4%), 39% in segment 2 (gradient range of 6-17%) and 22% in segment three (gradient range 4-6%) (Steve Todd, personal communication, 2003).

Pool Frequency

Pool frequencies, measured in channel widths/pool were 3.1 in segment 1, 1.6 in segment 2 and 3.3 in segment 4 (Steve Todd, personal communication, 2003).

Pool Quality
Pool quality is unknown.

Streambank Stability
Streambank stability was assessed in 1993 by Peter Bahls, Port Gamble S'Klallam Tribe, and Carol Bernthal, Point No Point Treaty Council, in three different river segments. The lower reach was 91.5% stable, segment 2 was 84.4% stable and segment 4 was 85.3% stable (Steve Todd, personal communication, 2003).

Sediment Input

Sediment Supply
As a result of intensive logging within the watershed, the channel has been scoured down to bedrock in the upper reaches, depositing large amounts of gravel in the lower depositional reach. Consequently the stream goes subsurface earlier in the season than prior to the intensive logging (TAG 2003).

Mass Wasting
Approximately 15% of the watershed is classified as steep, with generally erosive soils (USFS 1997). May 2003 reports 4.05% mass wasting in the watershed. Water runs over the ground quickly with little infiltration below the surface (TAG 2003). The TAG assumes that mass wasting is within the natural rate.

Road Density
Road density for the entire watershed is 4.8 miles of road per square mile of watershed. Road density is 0.23 miles of road per square mile of watershed within Olympic National Forest boundaries, which is a small amount of the watershed (USFS 1997). The known fish habitat is within private ownership (TAG 2003).

Riparian Zones

Riparian Condition
Approximately 58.09 % of the stream has a forested buffer. Fragmentation data indicates 2.09 breaks per stream mile (May 2003). Buffers are minimal in the middle section and to the break in slope in the lower section. The majority of the trees within the buffer are less than 20 years old (TAG 2003). Large woody debris recruitment potential is 62% poor, 3% fair and 35% good (USFS 1997).

Water Quality

Temperature
Port Gamble S'Klallam Tribe monitored water temperature near Highway 101 in 2001 (Labbe et al. 2002) and 2002 (Ted Labbe, unpublished data 2003) with results as follows:

Table 8. McDonald Creek Water Temperatures, 2001-2002. Data provided by Ted Labbe, PGST.

Stream/Location	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C	2002 AIMT °C	2002 7-DADMT °C
McDonald Creek	15.4	14.9	14.3	16.4	15.9

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT = 21-day average of the daily average temperature.

Temperature data was collected by the Washington Department of Ecology during the mid to late 1990s but was not readily available for this report. Four sites were monitored over several years including one in the lower reach above tidewater (anadromous reach), one above the mouth of the West Fork McDonald Creek (resident trout reach), one upstream below a right bank clearcut reach and one below a road crossing a few hundred meters upstream (Marty Ereth, personal communication, 2003).

Dissolved Oxygen

This parameter is a data gap.

Hydrology

Average rainfall in this watershed is 51.9 inches annually (May 2003). Approximately 1.8% of the precipitation regime is rain-on-snow events at elevations 1400 to 2900 feet. Approximately 83% lies within the lowland precipitation zone (USFS 1997). Low summer flows limit coho rearing potential. Any consumptive diversion of water should be discouraged (Williams et al. 1975).

Flow: Hydrologic Maturity

Approximately 23% of the stand age is between 4 and 40 years (USFS 1997). More than 50% of the watershed has been recently clear cut (TAG 2003).

Flow: Percent Impervious Surface

Approximately 2.1% of the watershed is impervious surface (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

Coho, chum and cutthroat utilize the lower watershed. Resident cutthroat trout utilize the upper watershed. Escapement goals have not been established for this watershed. This parameter is therefore a data gap.

Estuaries

Estuary function is impaired at the Highway 101 crossing/fill, and residential fill into the south side of the estuary. A rock jetty extends northward near the mouth of the small embayment and appears to serve no purpose. The jetty should be removed (TAG 2003).

Data Needs

- Collect channel condition data
- Collect water quality data
- Determine sediment supply
- Determine stock status

Action Recommendations

- Remove the rock jetty from the estuary.
- Broaden the Highway 101 crossing to reestablish estuary function
- Establish riparian zone

Fulton Creek

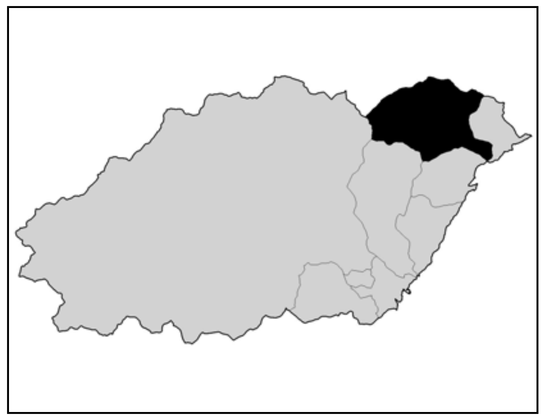

Figure 38. Fulton Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Fulton Creek, including the south fork, has total of approximately 9.0 stream miles. The headwaters originate in the 3000-foot level on the western slope of the Olympic Peninsula, terminating in Hood Canal between McDonald Creek and Schaerer Creek. Salmon utilize the lower watershed to the falls at river mile 0.9 (Williams et al. 1975). Steep concave headwaters drain the hillslopes controlled by bedrock geology followed downstream by a reduced gradient as the stream flows across and into a bench system formed by glacial deposits. A steep confined section follows downstream with steep cascade reaches emptying into a short alluvial fan. Stream density is 4.8 miles per square mile of watershed. There are 1.4 acres of wetlands located near the mouth. Of a total of 5,353 acres of watershed, 4,845 are within the Olympic National Forest. There are 130 acres of in-holdings within the National Forest boundaries (USFS 1997). Rainfall is approximately 73.4 inches per year (May 2003). Between 1955 and 1986, WDFW released coho juveniles into Fulton Creek (USFS 1997). Between 1979 and 1994, approximately 1,000,000 chum fry were released annually (WDFW 1994).

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration on Fulton Creek. There are two partial barriers (velocity barriers) within resident cutthroat habitat on USFS road number 2510 at both the North Fork and the South Fork crossings (Marc McHenry, personal communication, 2003).

Floodplains

Floodplain Connectivity

There are four areas of bank armoring and/or diking in the lower watershed. One dike appears to have no current purpose at about river mile 0.4 and should be removed. The remaining armoring protects a couple of houses and a road along the left bank (PNPTC, unpublished data, 2003). There is a long history of gabion baskets and log weirs (Marty Ereth, personal communication, 2003).

Loss of Floodplain Habitat

There are losses of floodplain habitat associated with dikes and bank armoring that are currently protecting houses. Fill associated with SR101 and immediately downstream of the highway on the left bank eliminates estuary habitat (TAG 2003).

Channel Condition

Fine Sediment

This parameter is a data gap.

Large Woody Debris

There are very few pieces of large woody debris in the lower reach to the falls (Steve Todd, personal communication, 2003). Within the 1,826 acres of riparian habitat, large wood recruitment is 6% poor, 38% fair and 56% good (USFS 1997).

Percent Pool

An average of 8.8% pools with 83% riffles and 1% glide habitats were determined by USFS surveys in three reaches. An average of 5.4% side channels were also reported (USFS 1997).

Pool Frequency/Pool Quality

These parameters are data gaps.

Streambank Stability

Streambank stability is unknown.

Sediment Input

Sediment Supply

The lower depositional reach is sediment rich and wood weirs have been strategically placed throughout as streambed controls. The TAG concluded that the sediment supply is within a natural rate.

Mass Wasting

Mass wasting potential in the watershed is 10.4% low, 7.3% medium and 14.1% high. Approximately 86% of the watershed area is in steep, generally erosive soils (USFS 1997). Actual documentation of mass wasting events is not available.

Road Density

Road density within the National forest is 1.72 miles of road per square mile of watershed (USFS 1997). For the entire watershed, May (2003) reports 1.9 miles of road per square mile of watershed.

Riparian Zones

Riparian Condition

Within the 1,826 acres of riparian habitat, large wood recruitment is 6% poor, 38% fair and 56% good (USFS 1997). The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature

Port Gamble S'Klallam Tribe collected water temperature data at the Highway 101 crossing during 2001 (Labbe et al. 2002) with results as follows:

Table 9. Fulton Creek Water Temperatures, 2001. Data provided by Ted Labbe, PGST.

Stream/Location	2001 AIMT ^{o}C	2001 7-DADMT ^{o}C	2001 21-DADT ^{o}C
Fulton Creek	17.3	16.9	14.7

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT = 21-day average of the daily average temperature.

Dissolved Oxygen

This parameter is a data gap.

Hydrology

Low summer flows limit coho rearing potential. Any consumptive use of water should be discouraged (Williams et al. 1975). Approximately 58% of the precipitation regime is rain-on-snow (USFS 1997).

Flow: Hydrologic Maturity

Approximately 9% of they watershed is hydrologically immature (less than 10% total crown closure and/or >75% of the crown in hardwoods or shrubs). Intermediate maturity (10-70% total crown closure and/or >75% of the crown in hardwoods or shrubs) is at 18% while 72% is hydrologically mature (>70% total crown closure and <75% of the crown cover in hardwoods or shrubs). Approximately 13% of the forest cover is between 4 and 40 years (USFS 1997). May (2003) reports 2.78 % of the watershed in recent clearcuts.

Flow: Percent Impervious Surface

Percent impervious surface is negligible in this watershed (PSCRBT 1995; May 2003).

Biological Processes

Nutrients (Carcasses)

The 0.8 miles of available habitat has supported as many as 100 coho and 1,000 fall chum in the past, although these numbers have not been observed since 1996. Escapement goals have not been set for Fulton Creek. Consequently, this parameter is a data gap.

Estuaries

The Highway 101 bridge over Fulton Creek restricts tidal influence and should be expanded (TAG 2003) while at the same time protecting the integrity of the estuarine channels west of the bridge that are utilized by juvenile chum, coho and chinook (Ron Hirschi, personal communication, 2003). Riprap and fill along the north side of the estuary should be removed. Historically there were islands of salt marsh, much of which has been eliminated by fill associated with the SR101 crossing and immediately downstream of the highway (TAG 2003).

Data Needs

- Assess fine sediments
- Evaluate channel conditions, i.e. large woody debris, pool frequency and pool quality
- Assess large woody debris recruitment potential and retention of wood in the channel in the lower reach to the falls
- Collect water quality data
- Evaluate nutrients

Action Recommendations

- Expand the Highway 101 bridge to restore estuary function
- Remove the old levee at about river mile 0.4
- Replace the culverts in the upper watershed
- Protect and restore riparian function in the lower reach to the falls

Schaerer Creek

Schaerer Creek, with a left bank tributary at river mile 0.5, totals 3.3 stream miles (Williams et al. 1975), consists of 4.0 miles of stream per square mile of watershed, encompasses a watershed area of 4,442 acres, including Triton Creek watershed (USFS 1997), and experiences an annual average of 56.9 inches of precipitation (May 2003). Small runs of coho and chum are observed in the lower 0.2 miles of accessible habitat, where an impassable falls restricts anadromous migration (Williams et al. 1975) while resident fish extend into the upper watershed (TAG 2003). USFS ownership encompasses 685 acres with 370 acres of private holdings within USFS boundaries. Schaerer Creek, entering Hood Canal at Beacon Point, is included in the Triton Creek watershed in the USFS watershed analysis for the Hamma Hamma sub-basin (USFS 1997). WDNR ownership in the Wacketickeh watershed alone is approximately 1,400 acres (Carol Thayer, unpublished data, 2003). The Jefferson County Refugia Study contains some information on this watershed (May 2003).

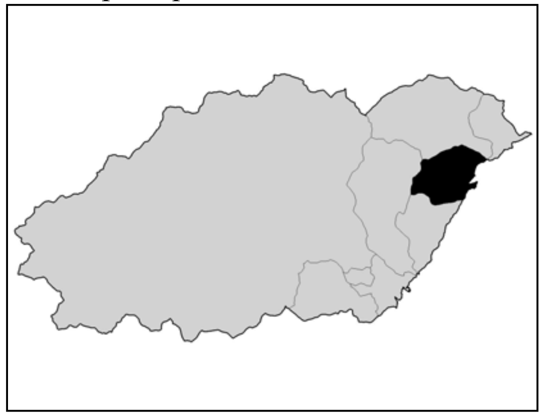

Figure 39. Schaerer Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous fish in this watershed. There are three barriers to resident trout migration on Department of Natural Resources roads (Carol Thayer, unpublished data, 2003).

Floodplains

Floodplain Connectivity

The Highway 101 crossing restricts tidal influence (TAG 2003).

Loss of Floodplain Habitat

Aside for the SR101 crossing, there are no floodplain modifications in this watershed (May 2003).

Channel Condition

Channel conditions have not been evaluated for the Schaerer Creek watershed.

Sediment Input

Sediment Supply
This parameter is a data gap.

Mass Wasting
Mass wasting potential is low at 97.5% with 0.5% moderate potential and 2% high potential. Approximately 16% of the watershed is steep with generally erosive soils (USFS 1997). WDNR ownership indicates soil mass wasting potential at 57% insignificant, 32% low potential, 9% moderate potential and 23% hi potential (Carol Thayer, unpublished data, 2003). An active slide in the upper watershed is due to a road failure event that happened over 30 years ago. In addition, a power line road culvert failed between seven and eight years ago which distributed abnormal levels of sediment into the creek. A road failure also occurred many years ago on Beacon Point Road (TAG 2003).

Road Density
There are two miles of road within the Olympic National Forest and 1.5 miles of National Forest roads outside of their boundaries. There are 3.98 miles of road per square mile of watershed (PNPTC, unpublished data, 2003a) with the highest concentration of roads downstream of the transmission lines and associated with a residential development (TAG 2003). Within the Olympic National Forest boundaries, road density is 1.9 miles of road per square mile of their ownership (USFS 1997).

Riparian Zones

Riparian Condition
Approximately 50% of the riparian area is mixed forest with riparian extent exceeding 51%. There are 2.49 breaks in the riparian canopy per stream mile (May, unpublished data, 2003). Total riparian acreage is 1,305 acres (4% of the watershed). From this riparian area, large woody debris recruitment potential is 29% poor, 31% fair and 40% good (USFS 1997). The Forest and Fish guidelines reserve 100 feet on either side of a type 4 stream for a riparian buffer (Herb Cargill, personal communication, 2003). The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature/Dissolved Oxygen
There is no water quality data for this watershed.

Hydrology

Flow: Hydrologic Maturity

Approximately 13% of the watershed is hydrologically immature, 23% intermediate maturity and 64% hydrologically mature. Approximately 19% of the watershed is between 4 and 40 years old. The rain-on-snow level at 1400 to 2900-foot elevation is 7.6% while 73% of the watershed is within the lowland precipitation zone (USFS 1997). Within WDNR ownership, approximately 62% is in stands older than 25 years (Carol Thayer, unpublished data, 2003). Clear cut harvest occurred in 1978 and 184 acres are due to be harvested in the near future (Herb Cargill, personal communication, 2003).

Flow: Percent Impervious Surface

Percent impervious surface is 0.85% in Schaerer Creek (May 2003) and 1% in Triton Creek (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

Small numbers of coho and chum utilize the lower 0.2 miles of the watershed. There are no established escapement goals for this watershed. This parameter is therefore a data gap.

Data Needs

- Collect channel condition data
- Collect water quality data
- Determine sediment supply
- Determine hydrologic maturity
- Evaluate riparian condition
- Evaluate nutrients

Action Recommendations

- Assess Highway 101 culvert and redesign without armoring/fill
- Remove the barrier on the DNR road

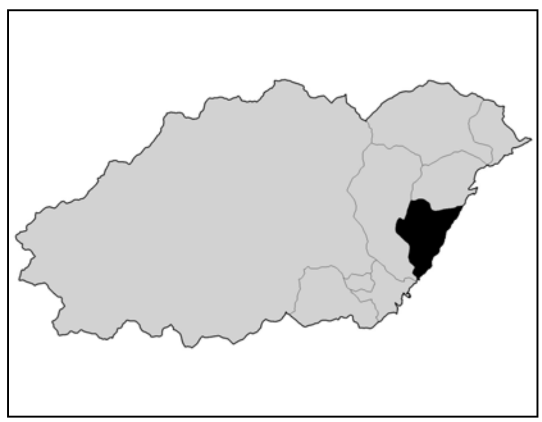

Figure 40. Unnamed Trib/Watershed at Mike's Beach. Map provided by Jennifer Cutler, NWIFC.

Unnamed Tributary at Mike's Beach

The unnamed tributary at Mike's Beach is 1.6 miles long (Williams et al. 1975) with steep gradient and limited anadromous fish use in the lower watershed. Approximately 20 coho and/or chum spawn in the lower watershed while resident trout have been observed in the upper watershed. Extensive logging and road building has recently occurred on private lands in the lower watershed (TAG 2003).

Access and Passage

Artificial Barriers

The two culverts in the lower watershed, one at an access road to a private campground and a double 4-foot box culvert at Highway 101, appear to be passable during most flows. The lower culvert includes tidal influence and coho have been observed between the two culvert systems. The lower access road should be redesigned to eliminate the stream crossing (TAG 2003).

Floodplains

Floodplain Connectivity/ Loss of Floodplain Habitat

The stream has been channelized in the lower reach to accommodate a campground, which has likely included some fill.

Channel Condition

Channel conditions have not been assessed in this watershed.

Sediment Input

Sediment Supply

There is very little gravel (mostly cobble and boulders) and little wood in the lower watershed (Marty Ereth, personal communication, 2003).

Mass Wasting

Mass wasting is unknown.

Road Density

Road density is poor, particularly in the lower watershed (TAG 2003).

Riparian Zones

Riparian Condition

Riparian condition has not been assessed.

Water Quality

Temperature/Dissolved Oxygen

Water quality is a data gap.

Hydrology

Flow: Hydrologic Maturity

Hydrologic maturity is poor in the lower watershed (TAG 2003).

Flow: Percent Impervious Surface
Percent impervious surface is unknown.

Biological Processes

Nutrients (Carcasses)
A small number of coho and/or chum spawn in the lower 0.2 miles up to the end of the campground where gradient becomes a barrier. However, there is not enough information to rate this parameter.

Estuaries
The estuary is adjacent to Mike's Beach Resort, much of which has been filled for cabins and a pier. At a minimum, the pier should be redesigned to allow sediment transport along the shoreline (TAG 2003).

Action Recommendations
- Redesign the campground access road to eliminate the stream crossing
- Properly decommission roads in the lower watershed, particularly those near the stream.
- Assess the Highway 101 culvert for fish access and remedy if necessary.

Waketickeh Creek

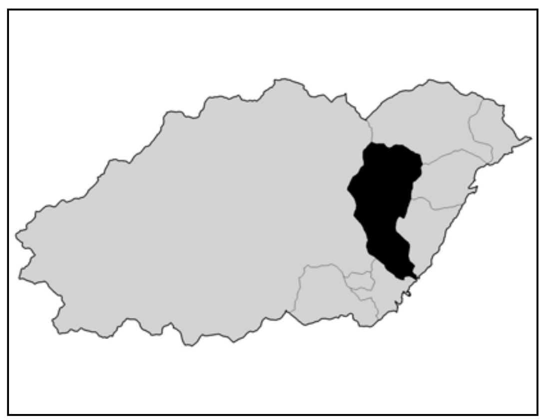

Figure 41. Waketickeh Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Wacketickeh Creek, and its major tributary at river mile 3.6, totals 8.2 miles of stream (Williams et al. 1975) with 0.4 miles of stream accessible to small populations of coho and chum (TAG 2003). The stream originates near the 3,000-foot level and enters Hood Canal north of the rural community of Eldon (Williams et al. 1975). Stream density is 4.1 miles of stream per square mile of watershed. There are 122 acres of lakes, ponds and wetlands within the lower port ion of the 5,772-acre watershed. USFS ownership encompasses 1,759 acres (USFS 1997). WDNR ownership encompasses 2,384 acres (Carol Thayer, unpublished data, 2003).

With the exception of the highest elevations in the headwaters, the Waketickeh basin is almost entirely within the area influenced by continental glaciation. Most channel segments are confined and directly connected to the adjacent hill or valley slopes. Three areas appear to have deep-seated landslides and/or inner gorge structures that likely exhibit strong influences or controls on channel structure and character (USFS 1997).

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration. There are six impassable crossings of streams that potentially support resident fish on WDNR lands (Carol Thayer, unpublished data, 2003).

Floodplains

Floodplain Connectivity

Fill has been placed behind riprap/armoring along both sides of the lower floodplain.

Loss of Floodplain Habitat

Where the floodplain exists, the lower reach has been channelized, armored and filled for approximately 360 feet on both sides of the stream. Highway 101 adds to the impacts with road fill within tidal influence.

Channel Condition

Fine Sediment

This parameter is a data gap.

Large Woody Debris

Large wood in this watershed has not been quantified. However, large woody debris recruitment potential from the riparian zone is 36% good, 48% fair and 16% poor (USFS 1997).

Percent Pool/Pool Frequency/Pool Quality

Pool data has not been collected for this watershed.

Streambank Stability

This parameter is a data gap.

Sediment Input

Sediment Supply

Sediment supply is unknown.

Mass Wasting

USFS reports 91% of the watershed low in potential for mass wasting, 2% a medium hazard and 6.5 percent rated a high hazard for mass wasting. Approximately 30% of the watershed is classified with steep, generally erosive soils (USFS 1997). WDNR reports 32% insignificant soil mass wasting potential, 30% low potential, 9% moderate potential, and 25% high potential (Carol Thayer, unpublished data, 2003). Actual mass wasting events have not been quantified.

Road Density

Road density for the entire watershed is 3.23 miles of road per square mile of watershed (PNPTC, unpublished data, 2003a). Road density for the Olympic National Forest only is 3.64 miles of road per National Forest ownership (USFS 1997). Many roads in the upper watershed have been there since 1939 (TAG 2003).

Riparian Zones

Riparian Condition

Approximately 52 percent of the riparian zone has a buffer of undetermined width with a 51% conifer/deciduous mix. There are 1.7 breaks in the riparian canopy per mile of stream (May 2003). The USFS has initiated a riparian reserve program along the stream corridors under their ownership (approximately 1/3 of the watershed) using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature/Dissolved Oxygen

Water quality has not been monitored in this watershed.

Hydrology

Approximately 32 percent of the watershed is within the rain-on-snow zone between 1400-foot and 2900-foot elevation. Eleven percent of the watershed is hydrologically immature (USFS 1997).

Flow: Hydrologic Maturity

Approximately 11% of the watershed is hydrologically immature, 17% intermediate maturity and 72% hydrologically mature. Sixteen percent of the forested watershed is between 4 and 40 years old (USFS 1997). Approximately 88% of WDNR lands are hydrologically mature (Carol Thayer, unpublished data, 2003). Approximately 61% of the watershed is forested with 55% conifer, 5% mixed and 1% deciduous forest. Approximately 2% has been recently clearcut (Chris May 2003) with an additional 120 acres slated for harvested now (TAG 2003).

Flow: Percent Impervious Surface

Impervious surface is negligible in the Wacketickeh watershed (Chris May 2003) and 1.6% in the Cummings Creek watershed (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap.

Estuaries

The historic salt marsh along the north side of the estuary has been filled and converted to rural housing and an unfenced wrecking yard. The Highway 101 crossing (bridge) has contributed to the filling of an historic tidal channel (TAG 2003).

Data Needs

- Assess channel conditions
- Determine sediment supply/mass wasting
- Collect water quality data

Action Recommendations

- Extend the Highway 101 bridge span and remove the associated fill
- Relocate the wrecking yard away from the shoreline

Hamma Hamma River

The Hamma Hamma River originates on the rugged eastern slope of the Olympic Mountains within the Olympic National Park and enters Hood Canal in northern Mason County south of the rural community of Eldon. The river and tributaries above Jefferson Creek, a right bank tributary at river mile 5.7, lie within Olympic National Forest boundaries. Limited sandstone, siltstone and slate bedrock formations are within the headwaters with the remainder of the watershed underlain by basalt-rich Crescent formation with glacial and alluvial deposits along the mainstem (Williams et al. 1975). Gradient is steep within rugged terrain in the upper six to seven miles and becomes more moderate to the canyon at about river mile 3.0. An impassable falls is at river mile 2.5 with a long series of cascades at approximately river mile 2.0 (USFS 1997). Below river mile 1.5 the stream gradient is moderate as it enters into a broad floodplain. The lower 0.6 miles is tidally influenced (Williams et al. 1975) and at high tide at least one small secondary channel connects the mainstem with a large tidal marsh, just north of the main channel (WDFW and PNPTT 2000).

The mainstem extends 17.8 miles with numerous tributaries contributing an additional 209 miles (USFS 1997). Average annual discharge is 559 cfs with a range of 39 to 6,010 for the years 1951 to 1979. There are two annual runoff peaks, one in November to February associated with winter rains and one in May to June associated with spring snowmelt (USFS 1997).

Anadromous salmon use the lower reach where pink, summer chum and chinook salmon spawn simultaneously during September. Late fall chum spawn in the mainstem and intertidally in Hamma Hamma Slough during December. Coho are present but production is limited by lack of suitable rearing habitat (Williams et al. 1975). Steelhead have been observed all the way to the falls at approximately river mile 2.5 and spawn between mid-February and mid-June (Thom Johnson, personal communication, 2003).

Nearly 95% of the watershed is in public ownership with 60% in managed forest and 34% protected within Olympic National Park or designated wilderness areas. WDNR owns 261 acres or 23% of the watershed (Carol Thayer, unpublished data, 2003). Private lands (5%) are concentrated in the productive lower anadromous reach near the river mouth and are managed primarily for timber harvest with aquaculture within the estuary and adjacent nearshore (WDFW and PNPTT 2000). The riverbed in the lower watershed is privately owned (TAG 2003).

The USFS watershed analysis defines their lower segment as extending from river mile 0.0 to approximately river mile 7.1. Their middle segment extends from river mile 7.1 to 13 and their upper segment extends from river mile 13 to the headwaters. Since their segments do no correspond to that of the LFA, it is difficult to directly analyze parameters for each reach using their data. However, wherever possible, their data was incorporated into the discussion, particularly in the upper watershed. USFWS data was used for the lower two segments of the mainstem as well as John Creek and a tributary to John Creek. The Summer Chum Conservation Initiative was used for the extent of summer chum habitat. Unpublished data from Chris May was also used where appropriate.

Hamma Hamma – Mouth to Canyon at River Mile 1.5

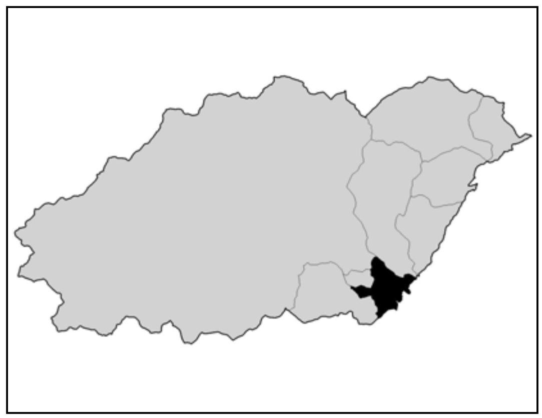

Figure 42. Hamma Hamma Watershed, RM 0.0 to 1.5. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration.

Floodplains

Floodplain Connectivity

In 1958, the landowner constructed a dike, placed riprap and dredged the mouth of the river. A 1930s timber cruise map reveals a 0.3-mile long side channel at river mile 0.8 that is no longer there. Diking and riprap reduce flood flow access to the floodplain (WDFW and PNPTT 2000). An Ecosystem Diagnosis and Treatment (EDT) model conducted for chinook in 2000-2001 determined that 10-40% of the lower river has been disconnected from its floodplain. Floodplain connectivity is good on the north side but has been disconnected from a slough on the south side (TAG 2003).

Loss of Floodplain Habitat

The majority of the floodplain is in agriculture, grazing or residential use, which has impacted 35% of the riparian zone (WDFW and PNPTT 2000). SR101 fills former tidal channel and salt marsh habitat, truncates the estuary, and disconnects tidal channels (TAG 2003).

Channel Condition

Fine Sediment

In 1996, USFWS habitat surveys, following modified TFW ambient monitoring protocols (Schuett-Hames et al. 1994) noted 3 large mounds ($6m^2$) of fine sediment placed approximately 900 meters upstream of tidal influence, possibly to deflect water away from an eroding left bank. Plumes of fines were observed leaving the uppermost mound. Fine sediments were also observed entering the river from large cut banks and mass wasting events 400 to 900 meters upstream of tidal influence (Carrie Cook-Tabor, unpublished data, 1996). Fine sediments have not been analyzed using McNeil sampling equipment.

Large Woody Debris

Most large wood has been removed from the lower watershed, reducing channel complexity and juvenile fish habitat. Large wood surveys conducted by USFWS indicate 0.12 pieces of wood per meter or 4.14 pieces per channel width (average 35.6 m wide). In the 1100 meters surveyed, there were 24 rootwads, 27 small logs, 40 medium logs and 37 large logs. There were no key pieces (Carrie Cook-Tabor, unpublished data, 1996). Reduction in riparian areas has reduced/eliminated recruitment sources for large wood (WDFW and PNPTT 2000).

Percent Pool

Pools are approximately 49% with 8% cascade, 33% riffle and 10% tailout of the total surface area within this segment (Carrie Cook-Tabor, unpublished data, 1996). EDT discussions determined the chinook habitat to contain 5 to 25% primary pools (Steve Todd, personal communication, 2003).

Pool Frequency

This parameter could not be evaluated from the data.

Pool Quality

Average residual pool depth within this segment is 1.14 meters (Carrie Cook-Tabor, unpublished data, 1996). The number of pools greater than one meter deep could not be determined from the data.

Streambank Stability

USFWS habitat surveys noted fine sediments entering the river from cut banks and mass wastings approximately 400 to 900 meters upstream of tidal influence. Smaller signs of erosion were observed upstream next to the roads and foot trails. Riprap, often an indication of unstable streambanks, has been heavily used around the large bend in the river and along the road, possibly causing the long, relatively even-bottomed, pools to form (Carrie Cook-Tabor, unpublished data, 1996).

Sediment Input

Sediment Supply

This segment is a response reach and there appears to be ample quantity of good spawning gravels between expansive pools throughout this reach. Streambed stability is unknown (TAG 2003).

Mass Wasting

USFS habitat surveys noted mass wasting approximately 400 to 900 meters upstream of tidal influence (Carrie Cook-Tabor, unpublished data, 1996). Whether this is above the natural occurrence level has not been determined.

Road Density

Road density within the mainstem between the mouth and the falls at river mile 2.5 is 3.2 miles of road per square miles of watershed (PNPTC, unpublished data, 2003a).

Riparian Zones

Riparian Condition

Riparian composition in the lower 6.6 miles of the river is 48% conifer, 22% mixed conifer/deciduous, 26% deciduous and 4% shrubs/grasses. Buffer widths vary with 58% greater than 132 feet wide, 0% between 66 and 132 feet wide, and 42% less than 66 feet wide (WDFW and PNPTT 2000). The EDT discussions determined that less than 25% of the riparian zone within the anadromous reach is functional (Steve Todd, personal communication, 2003).

Water Quality

Temperature

Long Live the Kings submitted temperature data for 2002. Water temperatures ranged between 4.05^{o}C and 13.96^{o}C (Long Live the Kings, unpublished data, 2003).

Dissolved Oxygen

Dissolved oxygen has not been measured in this watershed.

Hydrology

Flow: Hydrologic Maturity

Hydrologic maturity for this specific reach is unknown.

Flow: Percent Impervious Surface

Impervious surface is negligible throughout the watershed as a whole (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

Chinook, summer chum and winter steelhead are rated depressed, late fall chum and pink salmon are rated healthy, and coho are unknown (WDFW, draft in review, 2003). Two out of five stocks meet escapement goals and three do not.

Estuaries

The main channel today was a secondary channel historically. It has been straightened, channelized, diked and dredged. The freshwater has been routed away from the shellfish beds. The historic secondary channel, now the mainstem, was once an extended salt marsh with a spit crossing the mainstem. Pilings were placed on the spit itself to support a dike which has now eroded away. A large bulkhead and fill now accommodate a shellfish facility at the base of the historic spit. Channels appear to be reestablishing where the dike has failed (TAG 2003).

Approximately 13% of the estimated 368.5-acre historic delta is diked in three areas, accounting for a loss of 48 acres of juvenile salmonid rearing habitat. One filled area in the outer, southern corner of the delta accounts for a loss of 3.2 acres (1% of historic delta habitat). An estimated 2.4 acres of the mainstem distributary channel (where it crosses the outer intertidal area) has been dredged, and at least seven areas (2.2 acres) of aquaculture or other modifications of the delta surface are apparent from analysis of current aerial and oblique photos. Three jetties or pile dikes, totaling 0.4 miles in length, are evident in the delta. In addition, eight road and causeway segments, totaling 1 mile in length, transect the delta, the largest of which is the Highway 101 causeway that has caused a direct loss of habitat and restricted tidal action and fish movement across the delta (WDFW and PNPTC 2000). WSDOT should replace the Highway 101 causeway/bridge with an elevated structure that spans much of the delta to allow reestablishment of tidal channels and salt marsh habitat (TAG 2003). The apparent isolation of the north bank estuarine salt marsh from the main river by dredging and dike/road causeway construction at the river mouth has eliminated the connectivity of the river with this critical rearing habitat. As a result, outmigrating fry/smolts are forced directly into deepwater habitat to face predation risks and must reenter the marsh from the east from Hood Canal (WDFW and PNPTT 2000). To restore juvenile rearing habitat, the dike along the north, the dike along the mainstem and other minor dikes should be removed to regain lost salt marsh habitat and to restore estuary function. Once the existing mainstem dikes are removed, changes to the historic spit form should be monitored. The pilings on the spit should be removed. All armoring should be removed to allow the river to move back to its original channel and all tidal/stream channels should be restored (TAG 2003).

Data Needs

- Assess fine sediment
- Investigate aquaculture impacts to salmonids and freshwater impacts on aquaculture
- Assess channel conditions

Hamma Hamma River – River Mile 1.5 to Falls at River Mile 2.5

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration.

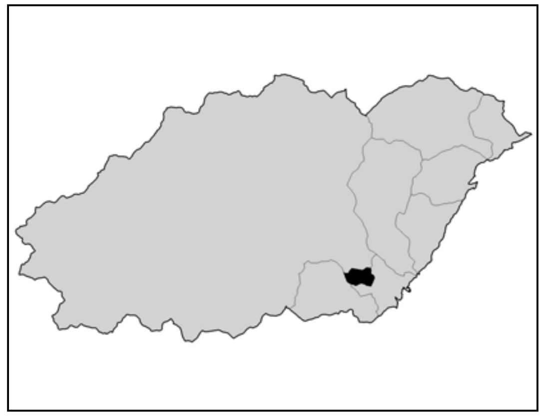

Figure 43. Hamma Hamma Watershed, RM 1.5 to 2.5. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

The majority of this reach is within a canyon so this parameter is not applicable.

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Most large wood has been removed from the lower watershed, reducing channel complexity and juvenile fish habitat. Large wood surveys conducted by USFWS indicate 4.39 pieces per channel width (average 28.3 m wide) in this reach. In the 380 meters surveyed, there were 6 rootwads, 15 small logs, 24 medium logs and 14 large logs. There were no key pieces (Carrie Cook-Tabor, unpublished data, 1996). Reduction in riparian areas has reduced and/or eliminated recruitment sources for large wood (WDFW and PNPTT 2000).

Percent Pool

USFWS habitat surveys indicate approximately 55% pools, 14% riffles, 24% cascades and 7% tailouts of the total surface area (Carrie Cook-Tabor, unpublished data, 1996).

Pool Frequency

Pool frequency could not be determined from the data.

Pool Quality

Average residual pool depth is 2.14 meters (Carrie Cook-Tabor, unpublished data, 1996). The number of pools greater than one meter deep cannot be determined from the data.

Streambank Stability

The majority of this segment is bedrock.

Sediment Input

Sediment Supply
Sediment supply is unknown.

Mass Wasting
Mass wasting in this segment is unknown.

Road Density
Road density is 3.2 miles of road per square mile of watershed between the mouth and the falls at river mile 2.5 (PNPTC, unpublished data, 2003a). Road density for this specific segment is unknown.

Riparian Zones

Riparian Condition
Riparian composition in the lower 6.6 miles of the river is 48% conifer, 22% mixed conifer/deciduous, 26% deciduous and 4% shrubs/grasses. Buffer widths vary with 58% greater than 132 feet wide, 0% between 66 and 132 feet wide, and 42% less than 66 feet wide (WDFW and PNPTT 2000). EDT discussions determined that riparian condition is similar to natural conditions (Steve Todd, personal communication, 2003).

Water Quality

Temperature
Water temperature is unknown.

Dissolved Oxygen
Dissolved oxygen data has not been collected for this watershed.

Hydrology

Flow: Hydrologic Maturity
Hydrologic maturity for this specific reach is unknown. However, the USFS has determined hydrologic maturity across a different spatial scale.

Flow: Percent Impervious Surface
Impervious surface is negligible throughout the watershed as a whole (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)
Chinook, summer chum and winter steelhead are rated depressed, late fall chum and pink salmon are rated healthy, and coho are unknown (WDFW, DRAFT IN REVIEW, 2003). Two out of five stocks meet escapement goals and three do not.

Hamma Hamma River – Upstream of the Falls

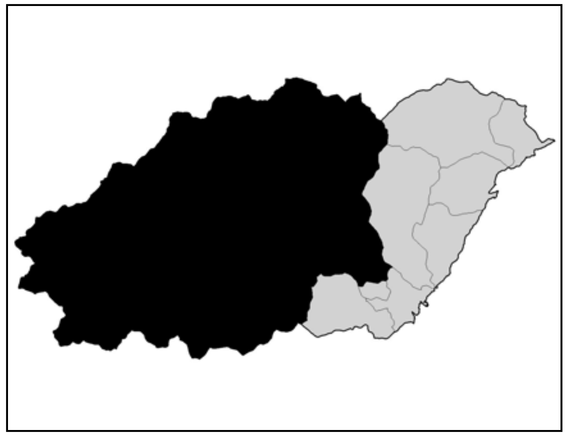

Figure 44. Hamma Hamma Watershed, above RM 2.5. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

There is no development within the floodplain in the low gradient reaches of the upper watershed (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

The USFS conducted large woody debris surveys in the upper watershed (mainstem and two tributaries) between river mile 6.4 and 14.3 in 1991 (USFS 1997) with results as follows:

Table 10. Upper Hamma Hamma Large Woody Debris, 1991. Data provided by USFS.

Stream/Segment	Large Wood/Mile	Small Wood/Mile
Hamma Hamma/1	0.8	13.5
Hamma Hamma/2	11.0	19.1
Jefferson/1	0	15.5
Jefferson/2	1.4	20.2
Jefferson/3	13.9	38.1
Washington/1	0	3.9
Washington/2	2.2	19.0

The watershed analysis did not specify the size of large and small wood. The TAG noted good wood quality and abundance in the floodplain section below river mile 6.4.

Percent Pool
The USFS conducted pool/riffle surveys in the upper watershed (mainstem and two tributaries between river mile 6.4 and 14.3 in 1992 (USFS 1997) with the following results:

Table 11. Upper Hamma Hamma Pools, 1991. Data provided by USFS.

Stream	% Pool	% Riffle	% Glide	% Side Channels	% Falls	Pool/ Mile
Hamma Hamma	4.4	77.1	15.1	2.8	0.6	4.4
Jefferson	16.8	71.2	2.9	8.0	1.1	3.83
Washington	1.6	84.3	11.1	2.8	0.2	2.44

Pool Frequency
Pool frequency could not be evaluated from the data.

Pool Quality
Pool quality is a data gap.

Streambank Stability
Streambank stability is a data gap.

Sediment Input

Sediment Supply
Sediment supply is unknown.

Mass Wasting
USFS analyzed mass wasting potential as follows:

Table 12. Hamma Hamma Mass Wasting Potential. Data provided by USFS, 1997.

Stream/Segment	Low Hazard	Medium Hazard	High Hazard	Rain-on-Snow	Stand Age 4-40yr	Steep Soils	Road Density
Lower Hamma RM 0-7.1	81%	6%	12.3%	36%	10%	22%	2.4
Middle Hamma RM 7.1-13	49%	21%	29%	50%	5%	73%	0.7
Upper Hamma Above RM 13	55%	16.5%	29%	34%	0%	81%	0.3

Road Density
Road density is unknown for this segment.

Riparian Zones

Riparian Condition
The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature
Temperature data has not been collected/analyzed for this reach.

Dissolved Oxygen
Dissolved oxygen data has not been collected for this reach.

Hydrology

Flow: Hydrologic Maturity
The USFS made the following assessment regarding hydrologic maturity (USFS 1997):

Table 13. Hamma Hamma Hydrologic Maturity. Data provided by USFS, 1997.

Stream/Segment	Immature	Intermediate	Mature
Lower Hamma Hamma, RM 0-7.1	9%	13%	79%
Middle Hamma Hamma, RM 7.1-13.0	21%	27%	52%
Upper Hamma Hamma, above RM 13.0	38%	32%	30%

NOTE: hydrologically immature = <10% total crown closure and/or >75% of the crown in hardwoods or shrubs; intermediate maturity = 10-70% total crown closure and <75% of the crown in hardwoods or shrubs; and hydrologically mature = >70% total crown closure and <75% of the crown cover in hardwoods or shrubs.

WDNR reports 64% hydrologic maturity on their lands (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface
Percent impervious surface is negligible (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)
Resident fish population estimates are unknown.

Hamma Hamma River – John Creek

John Creek is an important right bank tributary to the Hamma Hamma River at river mile 1.4. It has moderate gradient in the lower mile and increases in gradient progressing upstream. The stream is accessible to migrating salmon to approximately river mile 1.8 (Williams et al. 1975). There are 2.734 acres in the watershed with 70% in WDNR ownership (Carol Thayer, unpublished data, 2003).

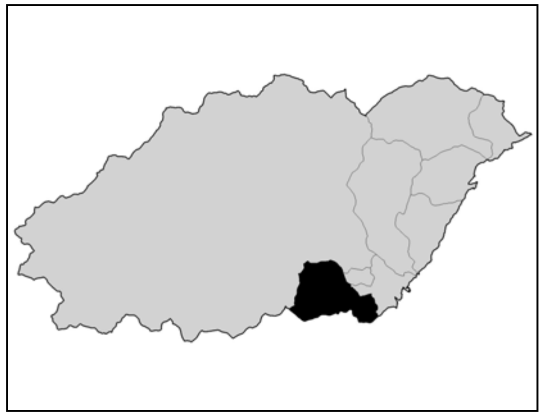

Figure 45. John Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration. Gravel accumulation near the mouth of John Creek, possibly due to logging practices in the watershed, presents a passage problem during low summer flows and has at times precluded summer chum from migrating upstream. A culvert on the north fork at the powerline road crossing could be a migration barrier to resident trout (Marty Ereth, personal communication, 2003). On WDFW lands, there are 3 impassable road crossings of streams that potentially support resident fish (Carol Thayer, unpublished data, 2003).

Floodplains

Floodplain Connectivity

Within the lower reach that is applicable to this parameter, EDT discussions determined that 10 to 40% of the stream is disconnected from its floodplain (Steve Todd, personal communication, 2003).

Loss of Floodplain Habitat

There is no development within the floodplain of lower John Creek, but there are parallel logging roads and road crossings, old gabions and water supply dams (TAG 2003).

Channel Condition

Fine Sediment

Fines in John Creek range between 11% and 18% (Ereth and Toal, unpublished data, 2003).

Large Woody Debris

A shift from conifer-dominated to alder-dominated riparian communities in this watershed has reduced the longevity and stability of large wood in the channel because alder logs are typically smaller than conifer and do not persist in streams (WDFW and PNPTT 2000). Large wood surveys conducted by USFWS in John Creek indicate a range of 1.79 to 3.87 pieces per channel width (average 9.49 and 9.16 m wide in the two segments surveyed) in this reach. Two tributaries were included in the surveys: South Fork John Creek and a right bank tributary to John Creek. Pieces of wood per channel width were 2.51 and 0.49 respectfully, although no key pieces and only 2 large pieces were noted (Cook-Taber 1996).

Table 14. John Creek Large Woody Debris, 1996. Data provided by Carrie Cook-Taber, USFWS.

Segment	Root-wads	Small Logs	Med Logs	Large Logs	Key Pieces	Total Pieces	Surv Lngth (m)	Avg Chan Width (m)	Pieces/ Chan Width	Key Pieces/ Chan Width
JohnCk1	17	85	114	39	10	255	1350	9.49	1.79	0.07
JohnCk2	4	21	47	27	8	99	234.3	9.16	3.87	0.31
SFJohn	0	12	10	2	0	24	100	10.45	2.51	0
RBTrib	1	9	6	0	0	16	100	3.05	0.49	0

It is important to note that the above summaries do not include logjam pieces. If the large wood found in the 10 log jams were included, the numbers of wood would be much higher. For example, when including logjams, a total of 18 and 11 key pieces were surveyed in each segment of John Creek respectively (Carrie Cook-Tabor, personal communication, 2003).

Percent Pool

The USFWS surveyed two segments in John Creek and one segment in each of two tributaries for percent pool with results as follows:

Table 15. John Creek Percent Pools, 1996. Data provided by Carrie Cook-Tabor, USFWS.

Segment	Pool	Riffle	Cascade	Tailout
John Creek 1	51	38	6	3
John Creek 2	41	41	16	
SF John Creek	38	31	29	
RB Trib	36	57	5	

Pool Frequency

Pool frequency cannot be determined from the data.

Pool Quality

Average residual pool depth ranged between 0.35m to 0.98m within the four segments surveyed (Carrie Cook-Tabor, unpublished data, 1996).

Streambank Stability

Streambank stability is unknown.

Sediment Input

Sediment Supply

Logging-induced landslides in the upper watershed have likely resulted in elevated sediment delivery rates to the channel. Lack of large wood in the channel eliminates gravel storage and it is consequently routed downstream. Gravel aggradation near the mouth impedes/delays summer chum migration into John Creek during low flow summer conditions and when flows are subsurface. In addition to impeding migration, there is also the risk of dewatering redds (WDFW and PNPTT 2000).

Mass Wasting

WDNR reports 16% of their lands have insignificant soil mass wasting potential, 10% low potential, 10% moderate potential and 49% high potential with no data for some of their lands (Carol Thayer, unpublished data, 2003). Logging road failures have created mass wasting events in both the upper and lower watershed above the natural rate (TAG 2003).

Road Density

Road density is 2.86 miles of road per square mile of watershed (PNPTC, unpublished data, 2003).

Riparian Zones

Riparian Condition

Riparian buffers are variable. In some cases 75 feet to 100 feet are remaining; in other cases, the riparian zone is harvested to the waters edge (TAG 2003). Washington Department of Natural Resources maintains one site potential tree height on type 4 streams (Herb Cargill, personal communication, 2003).

Water Quality

Temperature

Long Live the Kings collected temperature data near the mouth of John Creek. Temperatures in 2002 ranged from 3.36°C to 15.02°C. The months of July and August were consistently above 14°C (Long Live the Kings, unpublished data, 2003).

Dissolved Oxygen

Dissolved oxygen data has not been collected in this watershed.

Hydrology

Flow: Hydrologic Maturity

WDNR reports that 92% of their lands are hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface

Impervious surface is negligible in the John Creek watershed (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

WDFW released 875,000 fall chum fry annually into John Creek in the late 1980s and early 1990s. Hood Canal Salmon Enhancement Group has been conducting summer chum, chinook and winter steelhead stock restoration programs in the watershed for the past decade. Adult returns from these supplementation efforts have likely increased nutrients within this watershed (TAG 2003).

Action Recommendations:

- Restore estuary/delta function
    - Replace SR101 causeway/bridge with an elevated structure across the entire delta to restore tidal channels, sloughs and estuary function
    - Remove all levees/dikes, particularly the mainstem dike, the dike along the north side of the estuary, and other minor dikes to reestablish historic sloughs and tidal channels
    - Remove all armoring, to allow the river to move back to its original channel
    - Remove bulkhead and fill that protects the parking lot at the shellfish facility to restore salt marsh habitat
    - Remove pilings from existing sand spit
    - Monitor sand spit once dikes are removed
- Restore natural riverine function
    - Restore channel complexity; install logjams/large woody debris and retain existing wood in channel
    - Assess/reestablish connection of mainstem with north bank salt marsh
    - Remove levees
    - Analyze physical channel hydrology and hydraulics, mainstem
    - Analyze sediment budget on Johns Creek

  Assess, protect, restore riparian

  Assess/stabilize/monitor sediment sources
    - Remove/repair roads
    - Abandon logging on steep slopes

LILLIWAUP SUB-BASIN

The Lilliwaup sub-basin lies to the south of the Hamma Hamma, Jorsted and Eagle Creek watersheds and to the north and east of the Skokomish and Sund Creek watersheds along the western shore of Hood Canal in northwestern Mason County. The Lilliwaup sub-basin includes Jorsted Creek (WRIA 16.0248), Eagle Creek (WRIA 16.0243), Lilliwaup Creek (WRIA 16.0230), Little Lilliwaup Creek (WRIA 16.0228), Sund Creek (WRIA 16.0226), Miller Creek (WRIA 16.0225), Clark Creek (WRIA 16.0224), Finch Creek, (WRIA 16.0222), and Hill Creek (WRIA 16.0221). The following reaches were identified by the TAG for this analysis:

- Jorsted Creek, entire watershed
- Eagle Creek, entire watershed
- Lilliwaup Creek, mouth to falls at river mile 0.7
- Lilliwaup Creek, upstream of falls at river mile 0.7
- Little Lilliwaup Creek, entire watershed
- Sund Creek, entire watershed
- Miller Creek, entire watershed
- Clark Creek, entire watershed
- Finch Creek, entire watershed
- Hill Creek, entire watershed

Jorsted Creek

Figure 46. Jorsted Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Jorsted Creek is 3.8 miles long (Williams et al. 1975) and, with Ayock Creek, drains an area of 4,519 acres (USFS 1997). Stream density is 3.5 miles of stream per square mile of watershed and there are 26 acres of lakes, ponds and wetlands (USFS 1997). For the most part, the terrain is rugged and gradient is steep, so salmon utilization is restricted to the lower reaches of lower gradient. There is ample gravel for spawning but the steep gradient and periodic instability tends to reduce productivity. Logging and recreational land use occurs in the upper watershed and residential development in the lower watershed (Williams et al. 1975). The Jorsted Creek watershed encompasses 3,283 acres and the Ayock Creek watershed encompasses approximately 802 acres. WDNR ownership in the Jorsted Creek is 2,192 acres or 67% of the watershed. WDNR ownership in the Ayock Creek watershed is 377 acres or 47% of the watershed (Carol Thayer, unpublished data, 2003). The USFS has included a small independent tributary, Ayock Creek, which flows into Hood Canal at Ayock Point, in their Jorsted Creek watershed analysis (USFS 1997).

Access and Passage

Artificial Barriers

There are no known artificial barriers to anadromous migration on Jorsted Creek although there are two impassable culverts within resident fish habitat (Carol Thayer, unpublished data, 2003). A culvert at the Highway 101 crossing is a total barrier to fish migration on Ayock Creek (TAG 2002).

Floodplains

Floodplain Connectivity

The broad alluvial fan in the lower watershed indicates the mouth of the creek historically moved north and south extensively. Today, extensive armoring, levees and residential fill extend along both sides of the lower river and have eliminated former floodplain connectivity (TAG 2003).

Loss of Floodplain Habitat

Residential development and associated fill borders the lower floodplain. Highway 101 adds significant impacts with associated fill (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large woody debris surveys have not been conducted but personal observation indicates there is no large wood within the anadromous reach. There are logjams upstream where gradient is between 4% and 8% (TAG 2003). Large woody debris recruitment potential is 24% poor, 57% fair and 19% good on USFS lands (USFS 1997) but poor throughout the lower channel (TAG 2003).

Percent Pool/Pool Frequency/Pool Quality

Pool data has not been collected.

Streambank Stability

Streambank stability may be compromised where the USFS road parallels the creek, increasing the potential for erosion (TAG 2003).

Sediment Input

Sediment Supply

Sediment supply is unknown.

Mass Wasting

Mass wasting potential is included in the USFS watershed analysis, although actual mass wasting events have not been quantified. Mass wasting potential is included in the USFS watershed analysis. Approximately 95% of the area is classified low hazard, 1% medium hazard, and 3.6 % high hazard. In addition, 8% of the watershed is in steep, generally erosive soils with 11% of the watershed influenced by rain on snow events (USFS 1997). Soil mass wasting potential on WDNR lands in Jorsted Creek is 42% insignificant potential, 16% low potential, 15% moderate potential and 20% high potential. Soil mass wasting potential on WDNR lands in Ayock Creek are 65% insignificant potential, 1% low potential, and 34% high potential (Carol Thayer, unpublished data, 2003). A road failure on recently decommissioned USFS Road #24 between river mile 1 and 2 on Jorsted Creek has the potential for continued failure, which will greatly impact the stream (TAG 2003).

Road Density

Road density is 4.3 miles of road per square mile of watershed within the Jorsted drainage and 8.44 miles of road per square mile of watershed within the Ayock watershed (PNPTC, unpublished data, 2003a).

Riparian Zones

Riparian Condition

Riparian condition has not been determined. In terms of management, the USFS has initiated a riparian reserve program along the stream corridors within their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002). Within the 1,189-acre riparian zone, large woody debris recruitment potential is 24% poor, 57% fair and 19% good (USFS 1997).

Water Quality

Temperature/Dissolved Oxygen

Water quality data has not been collected and/or analyzed.

Hydrology

Flow: Hydrologic Maturity

Hydrologic immaturity is 13%, 4% is intermediate maturity and 83% is hydrologically mature. Approximately 21% of the watershed is between 4 and 40 years of age (USFS 1997). Approximately 79% of the WDNR ownership in Jorsted Creek and in Ayock Creek is hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface

Percent developed impervious surface is negligible in the Jorsted Creek watershed but is 6.2% in the Ayock watershed, due to the Stetson Resort development (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)
Escapement goals have not been established for Jorsted Creek. Chum escapement has remained good, often exceeding 1,000 fish throughout the anadromous reach.

Estuaries

Historic tidal channels have been eliminated due to the manipulation of the mouth of Jorsted Creek. Approximately 4.25 acres of salt marsh have also been lost due to Highway 101 fill, buildings and roads. Numerous pilings are within the estuary and nearshore as part of a log storage operation that is no longer functioning (TAG 2003).

Data Needs

- Collect pool data
- Determine riparian condition

Action Recommendations

- Restore estuary function
  NOTE: Acquisition and/or conservation easements may be needed to accomplish the following restoration activities:
  - Assess Highway 101 and modify if necessary
  - Soften shoreline where necessary
- Develop local stewardship program, i.e. replant the riparian zone with native species

Eagle Creek

Eagle Creek enters Hood Canal between Ayock Point to the north and Lilliwaup Bay to the south. The mainstem is 3.2 miles long with an additional 5.3 miles in tributaries (Williams et al. 1975), draining a watershed area of 4,194 acres with a stream density of 2.9 miles of stream per square mile of watershed. There are 140 acres of lakes, ponds and streams (USFS 1997). Melbourne Lake drains into Eagle Creek and was dammed for coho production in the 1950s. Although fish are no longer supplemented from the lake, the dam is still there. The west end of the lake was once a cranberry bog (TAG 2003). Downstream of the lake, terrain is rugged and the gradient is steep, except in the lower reaches. The watershed is sparsely developed with logging and recreational uses in the upper watershed and commercial and residential development along the shoreline of Hood Canal. The steep gradient and periodic instability have reduced chum and coho spawning productivity in the lower watershed. Anadromy extends to river mile 1.7 or 1.8. The majority of the watershed (76%) is within DNR boundaries (Carol Thayer, unpublished data, 2003).

Access and Passage

Artificial Barriers

There are no known artificial barriers on mainstem Eagle Creek. There is a partial barrier culvert on the tributary that joins the large wetland/pond just upstream of SR101 (Marty Ereth, personal communication, 2003).

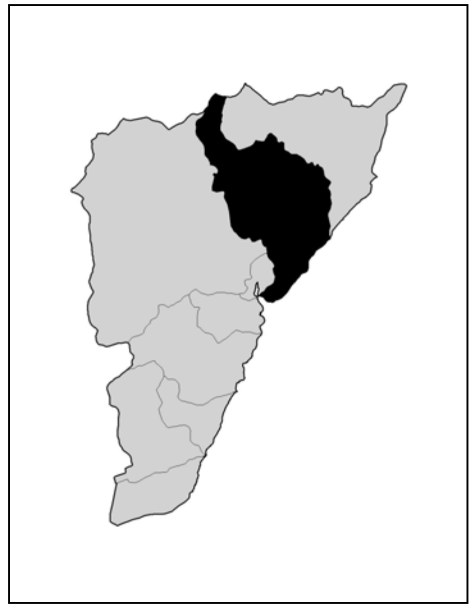

Figure 47. Eagle Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity

Armoring downstream of river mile one is on both the right bank and the left bank. Remnant gabion controls are visible throughout this reach. A large pond, historically a salt marsh, is connected with the stream behind a tavern and parking lot.

Loss of Floodplain Habitat

Highway 101 and the parking lot fill have eliminated historic salt marsh habitat in the estuary. It appears that the rest of the floodplain is intact (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Large wood in the stream is patchy but there are some good logjams (TAG 2003). Large woody debris recruitment potential is 26% poor, 44% fair and 30% good (USFS 1997).

Percent Pool/Pool Frequency/Pool Quality

Pools have not been assessed.

Streambank Stability

Streambanks are well vegetated and are consequently stable (TAG 2003).

Sediment Input

Sediment Supply

There is ample suitable gravel for spawning but the steep gradient and periodic instability tends to reduce productivity. Sediment from a right bank tributary that is downcutting contributes to gravel in the response reaches, whether this exceeds normal levels in unknown (TAG 2003).

Mass Wasting

Mass wasting potential based on slope morphology is approximately 99% low hazard, 0.2% medium hazard and 0.9 high hazard. Approximately 5% of the watershed area consists of steep, generally erosive soils (USFS 1997). Hillsides are steep and erosive above river mile 1.5 (Herb Carghill, personal communication, 2003). WDNR reports approximately 58% of their ownership experiences insignificant soil mass wasting potential, 14% low potential, 2% moderate potential, and 22% high potential (Carol Thayer, unpublished data, 2003). Actual mass wasting events have not been quantified.

Road Density

Road density is 3.2 miles of road per square mile of watershed (PNPTC, unpublished data, 2003a).

Riparian Zones

Riparian Condition

Riparian area of 925 acres has large woody debris potential of 26% poor, 44% fair and 30% good (USFS 1997). DNR protects two site potential tree heights on fish bearing streams and one site potential tree height on non-fish bearing streams (Herb Carghill, personal communication, 2003).

Water Quality

Temperature

Temperature data has not been analyzed.

Dissolved Oxygen

Dissolved oxygen is a data gap.

Hydrology

Flow: Hydrologic Maturity

Approximately 8% of the watershed is hydrologically immature, 3% is intermediate maturity and 88% is hydrologically mature. Stand age is 22% between 4 and 40 years of age. Approximately 91% of the watershed is in the lowland precipitation zone with 0% affected by rain on snow events (USFS 1997). WDNR reports 79% of their ownership is hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface

Impervious surface is less than 1% in the Eagle Creek watershed (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

WDFW released 1,000,000 unfed chum fry through remote site incubators in the late 1980s and early 1990s (WDFW 1994). Numbers of adult spawning chum reached an excess of 6,000 in the early and mid-1990s but have not reached such high numbers since that time (WDFW, spawning ground data, 1999). Fair numbers of coho utilize all of the accessible portions of Eagle Creek, the right bank tributary and several small unmapped left bank tributaries (Marty Ereth, personal communication, 2003).

Estuaries

SR101 and the tavern parking lot fill have impacted estuary function and eliminated salt marsh and tidal channels. The freshwater pond was historically a tidal lagoon. See the nearshore discussion for more detail.

Data Needs

Action Recommendations

- Restore estuary function (see nearshore discussion)
  NOTE: Acquisition and/or conservation easements may be needed to accomplish the following restoration activities:
    - Assess Highway 101 crossing and modify if necessary
- Assess, retain and restore complexity, i.e. large woody debris

Lilliwaup Creek

Lilliwaup Creek mainstem is 6.9 miles long with an additional 6.3 miles of tributaries (Williams et al. 1975) draining a watershed area of 17.8 square miles or 11,408 acres (USFS 1997). The watershed is underlain by the basalt-rich Crescent formation and is fed by extensive wetlands (over 910 acres) associated with Price Lake and upper Lilliwaup valley (PSCRBT 1995). The remaining upper and middle gradients are generally steep. Below a large falls at river mile 0.7 the stream flows through a large well-developed floodplain (WDFW and PNPTT 2000).

The upper watershed is primarily forest lands with 89% in public ownership (2,189 acres or 19% of the total watershed acreage within Olympic National Forest and approximately 47% within WDNR ownership) and 7% in private ownership (PSCRBT 1995). By the early 1930s, the entire watershed was logged (Amato 1996 cited in WDFW and PNPTT 2000). Much of the lower floodplain has been converted to transportation and residential use.

Summer chum, chinook, pink salmon, coho, and fall chum spawn in Lilliwaup Creek. A private hatchery operated by Long Live the Kings has been supplementing summer chum populations using native broodstock since the early 1990s.

Lilliwaup Creek, Mouth to Falls at River Mile 0.7

Access and Passage

Artificial Barriers

There are no artificial barriers to salmon migration.

Floodplains

Floodplain Connectivity

The road along the right bank of the creek and estuary is supported by armoring/riprap. At some point during the 1960s or 1970s, approximately 600 feet of the stream at river mile 0.2 was straightened and dredged to route floodwaters away from homes on the east side of the creek (Rick Endicott, personal communication, cited in WDFW and PNPTT 2000).

Figure 48. Lilliwaup Watershed, RM 0.0-0.7. Map provided by Jennifer Cutler, NWIFC.

Loss of Floodplain Habitat

Fill from SR101 impacts estuary function and should be removed and the highway span increased to allow tidal movement and sediment exchange. An impounded trout pond, with associated diking and infrastructure, has further reduced estuary function. Fill along the south side of the estuary for development and an access road has reduced the size of the estuary. A right bank tributary has been placed into a culvert from the pool at the base of the falls, under the developed properties and the road, prior to entering the estuary (TAG 2003). Approximately 48% of the riparian zone (by area) in this segment has been converted to roads (28%), agriculture (20%) and residential development (2%) (WDFW and PNPTT 2000).

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

The lack of large wood in the lower channel contributes to reduced channel complexity and raises the potential for channel instability and redd scour during peak flow events. Loss of riparian habitat has decreased large wood recruitment for both the creek and the estuary (WDFW and PNPTT 2000).

Percent Pool/Pool Frequency/Pool Quality

Pool data has not been collected.

Streambank Stability

The lower watershed is a slide prone area with evidence of slumping. The south side is stable only because of the armoring that protects the access road (TAG 2003).

Sediment Input

Sediment Supply

There is ample spawning gravel throughout the entire reach (TAG 2003).

Mass Wasting

There are no known mass wasting events in the lower watershed (TAG 2003).

Road Density

Road density is 3.09 miles of road per square mile of watershed for the entire watershed (PNPTC, unpublished data, 2003). There are numerous roads associated with Christmas tree farms (TAG 2003).

Riparian Zones

Riparian Condition

Approximately 79% of the forested buffer in this segment is dominated by medium-sized trees (12-20-inch dbh) of mixed composition. The remaining 21% lacks a buffer altogether. Fifty-two percent of the buffer is >132 feet in width, while 48% is < 66 feet wide and/or sparse. Approximately 48% of the riparian zone (by area) in this segment has been converted to roads (28%), agriculture (20%) and residential development (2%) (WDFW and PNPTT 2000).

Water Quality

Temperature

Temperature data has not been analyzed.

Dissolved Oxygen

Dissolved oxygen is a data gap.

Hydrology

A private landowner operates a small hydroelectric power facility immediately below the falls at river mile 0.7. Water is diverted from the falls and returned to the stream at the base of the falls.

Flow: Hydrologic Maturity

The discussion for the lower watershed has been combined with the discussion for the upper watershed. Approximately 13% of the watershed is hydrologically immature, 14% is intermediate maturity and 73% is hydrologically mature. Watershed wide, 10% of the forested area is between 4 and 40 years old (USFS 1997).

Flow: Percent Impervious Surface
Percent impervious surface is negligible in the upper watershed (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)
Summer chum are the only species rated by SaSI (critical) although fall chum, coho, chinook, and pink salmon utilize the lower watershed. Escapements have been good in the last few years but data have not been compared to historic conditions (TAG 2003).

Estuaries

The historic delta was approximately 48.2 acres. A diked area and pond associated with the fish hatchery accounts for a total loss of 2 acres (4%), while fill for residential development of the south side of the estuary accounts for a loss of 1.2 acres (2.6%). In addition, the 0.12 mile long Highway 101 causeway has restricted estuary function and tidal circulation, constrained distributary channels and eliminated habitat area. Although only a small percent of the historic delta has been impacted, the location of these habitat alterations has likely contributed to a disproportionately large effect on the overall functional value of the estuary as juvenile rearing and transition habitat for juvenile salmonids (WDFW and PNPTT 2000).

Data Needs

- Determine fine sediments
- Collect pool data

Lilliwaup Creek, Upstream of the Falls at River Mile 0.7

Access and Passage

Artificial Barriers
A culvert in the upper watershed at Lilliwaup Campground on USFS Road #24 is a barrier problem. The creek was rerouted at the culvert, fluctuated in its direction, and eventually carved a new channel (TAG 2003). WDNR reports 4 passage barriers to resident fish on their lands (Carol Thayer, unpublished data, 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
The upper watershed is an extensive interconnected wetland complex that is still intact. The outlet from Price Lake is a falls, which then flows into a steep canyon (TAG 2003).

Channel Condition

Fine Sediment
Fine sediment is a data gap.

Large Woody Debris

Large woody debris recruitment potential for the entire watershed is 26% poor, 36% fair and 39% good (USFS 1997). Actual wood abundance and quality is unknown.

Percent Pool/Pool Frequency/Pool Quality

Pool data has not been collected for this segment.

Streambank Stability

There are no known streambank failures (TAG 2003).

Sediment Input

Sediment Supply

Sediment supply is unknown.

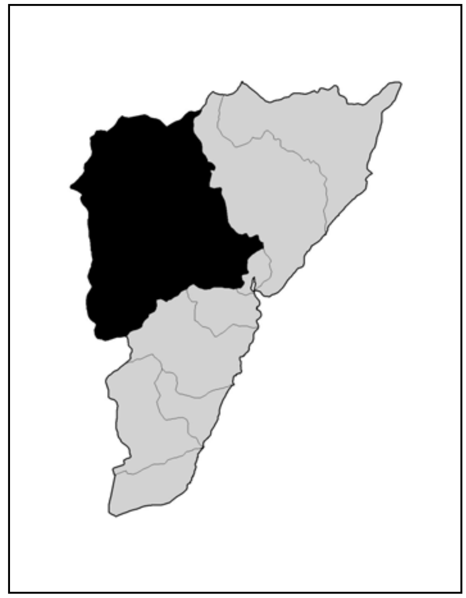

Figure 49. Lilliwaup Watershed, above RM 0.7. Map provided by Jennifer Cutler, NWIFC.

Mass Wasting

Mass wasting potential, based on slope morphology, places 92% in the low hazard category, 2% in the medium hazard category and 5.5% in the high hazard category. Approximately 15% of the watershed consists of steep, generally erosive soils and 21% is affected by rain-on-snow events (WDFW and PNPTT 2000). WDNR reports 67% of their lands indicate insignificant soil mass wasting potential, 8% low potential, 2% moderate potential and 19% high potential (Carol Thayer, unpublished data, 2003).

Road Density

Road density is 3.09 miles of road per square mile of watershed for the entire watershed (PNPTC, unpublished data, 2003). Road density for the Olympic National Forest is 2.9 miles of road per square mile of National Forest ownership. There are numerous roads associated with Christmas tree farms (TAG 2003).

Riparian Zones

Riparian Condition

Riparian acreage is 2,925 acres with large woody debris recruitment potential for the entire watershed calculated at 26% poor, 36% fair and 39% good (USFS 1997). Approximately 89% of the watershed is in public ownership (USFS 19%, WDNR 70%). Within public ownership, riparian zones are protected with two site potential tree heights along fish bearing streams and one site potential tree height along type 4 streams (TAG 2003).

Water Quality

Temperature/Dissolved Oxygen
Water quality has not been measured in the upper watershed.

Hydrology

Flow: Hydrologic Maturity
Approximately 13% of the watershed is hydrologically immature, 14% is intermediate maturity and 73% is hydrologically mature. Watershed wide, 10% of the forested area is between 4 and 40 years old (USFS 1997). WDNR reports that 75% of their ownership in this watershed are hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface
Percent impervious surface is negligible in the upper watershed (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)
Resident fish population estimates are unknown in the upper watershed.

Data Needs
- Assess channel condition, including large wood and pools

Action Recommendations
- Restore estuary function
  NOTE: Acquisition and/or conservation easements may be needed to accomplish the following activities:
  - Expand Highway 101 bridge span
- Protect the upper watershed wetlands and assess their relationship to summer low flows
- Restore complexity
  - Look for areas to restore floodplain connectivity
  - Conduct habitat survey in anadromous reach, including channel stability
  - Install logjams/LWD
- Daylight the right bank tributary that flows under development into the estuary
- Assess, protect, restore riparian conditions in the lower reach

Little Lilliwaup Creek

Little Lilliwaup Creek is 1.05 miles long with stable water supply from apparent spring sources (Williams et al. 1975. There are 981 acres in the watershed with 719 acres (73% in WDNR ownership (Carol Thayer, unpublished data, 2003). The south fork becomes intermittent in some years (TAG 2003). The stream flows into Hood Canal immediately to the south of Lilliwaup Bay.

Access and Passage

Artificial Barriers

There are no known artificial fish passage barriers to anadromous fish on this stream (TAG 2002). There is one barrier to resident fish migration on WDNR lands (Carol Thayer, unpublished data, 2003).

Figure 50. Little Lilliwaup Watershed. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity

The south side of the floodplain is functioning well (TAG 2003).

Loss of Floodplain Habitat

Armored banks protect a house at the mouth of the stream and protect an upstream culvert as well. The Highway 101 crossing has filled some of the lower floodplain and historic estuary.

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large wood is abundant and of good quality upstream of the culvert but sparse below. A large logjam at one time inhibited fish passage, but has naturally reconfigured and is no longer a problem (TAG 2003).

Percent Pool/Pool Frequency/Pool Quality

Pool data has not been collected.

Streambank Stability

Streambanks appear stable (TAG 2003).

Sediment Input

Sediment Supply

There are ample good spawning gravels (TAG 2003).

Mass Wasting

WDNR reports 43% of their ownership indicates insignificant mass wasting potential, 32% low potential, 14% moderate potential and 10% high potential (Carol Thayer, unpublished data, 2003). There has been some mass wasting on a northern tributary but is assumed to be natural (TAG 2003).

Road Density
Road density is a data gap.

Riparian Zones

Riparian Condition
Riparian condition is good with an overstory throughout the watershed, except in the vicinity of a house and lawn (TAG 2003).

Water Quality

Temperature
Temperature data has not been analyzed.

Dissolved Oxygen
Dissolved oxygen is a data gap.

Hydrology

Flow: Hydrologic Maturity
WDNR reports that 53% of their ownership is hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface
This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)
WDFW released 1,000,000 fall chum fry through their remote site incubator program in the late 1980s and early 1990s (WDFW 1994). Adult fall chum spawners have returned in good numbers (WDFW, spawning ground data, 1999) and summer chum have been observed spawning in the stream in recent years (Marty Ereth, personal communication, 2003).

Estuaries

Highway 101 has filled the intertidal/mudflat. The existing box culvert restricts transport of debris and juvenile migration when the tide is out and should be replaced with a bridge (TAG 2003).

Data Needs

- Determine fine sediments

- Assess large woody debris quantity and quality
- Collect pool data

Action Recommendations

- Restore estuary function
  NOTE: Acquisition and/or conservation easements may be needed to accomplish the following restoration activities:
  - Replace existing box culvert with a bridge
- Plant riparian with native vegetation along private property

Sund Creek/Miller Creek

Sund Creek is 2.7 miles long but flows only seasonally from late November through mid-May, which restricts salmon productivity. Terrain is rather rugged and land use has been limited to logging in the upper watershed and residential development along the shoreline of Hood Canal. The gradient is less steep in the lower 0.5 miles of stream where small populations of coho and chum spawn (Williams et al. 1975). There are approximately 1,795 acres in Sund Creek watershed, the majority of which (83%) is in DNR ownership (Carol Thayer, unpublished data, 2003).

Figure 51. Sund and Miller Watersheds. Map provided by Jennifer Cutler, NWIFC.

Miller Creek is 2.7 miles long but flows only seasonally from late November through mid-May, which restricts salmon productivity. Terrain is rather rugged and land use has been limited to logging in the upper watershed and residential development along the shoreline of Hood Canal. The gradient is less steep in the lower watershed where small populations of coho and chum spawn (Williams et al. 1975). It is unknown whether fish migrate above a falls/cascade at approximately river mile 0.2. A falls at river mile 1.2 is a known barrier (Streamnet). The Miller Creek watershed is 1,014 acres with 651 acres (64%) in WDNR ownership (Carol Thayer, unpublished data, 2003).

The USFS combines Sund and Miller creeks in their watershed analysis, although there is no USFS ownership (USFS 1997).

Access and Passage

Artificial Barriers

There are no known artificial barriers on the anadromous reaches of Sund Creek or Miller Creek (TAG 2002). There is one barrier in the resident reach of Miller Creek on WDNR lands (Carol Thayer, unpublished data, 2003).

Floodplains

Floodplain Connectivity

Miller Creek has been cemented near the mouth. Flooding necessitates the use of sandbags. Diking disconnects the floodplain on Sund Creek (TAG 2003). The lower anadromous reaches on both Sund and Miller creeks are seasonal but the upstream resident trout reaches have perennial flow (Marty Ereth, personal communication, 2003).

Loss of Floodplain Habitat

Sund Creek is developed on both sides of the anadromous reach with diking and fill within the floodplain.

Channel Condition

Fine Sediment

This parameter is a data gap.

Large Woody Debris

Large wood is not present within the anadromous reach of Sund or Miller creeks. Within the more natural canyon reaches of both systems, wood is present (TAG 2003). Large woody debris recruitment potential is 27% poor, 39% fair and 34% good for Sund and Miller creeks combined (USFS 1997).

Percent Pool/Pool Frequency/Pool Quality

Pool data has not been collected for pools.

Streambank Stability

Streambanks are unstable within the canyon reach of Miller Creek. There are numerous small failures with undercut banks (TAG 2003).

Sediment Input

Sediment Supply

Both Sund and Miller Creeks have sparse spawning gravels with a lot of cobble (TAG 2003).

Mass Wasting

Mass wasting potential for Sund and Miller creeks combined is 99.6% low hazard, 0.04% medium hazard and 0.4% high hazard. Approximately 10% of the combined watersheds have steep, generally erosive soils with 8.6% of the watershed affected by rain-on-snow (USFS 1997). Soil mass wasting potential on WDNR lands in the Sund Creek watershed is 42% insignificant potential, 19% low potential 9% moderate potential and 29% high potential. Soil mass wasting potential on WDNR lands in the Miller Creek watershed is 37% insignificant potential, 16% low potential, 8% moderate potential and 43% high potential (Carol Thayer, unpublished data, 2003). Stormwater from a planned development could affect hydrology and streambank stability (TAG 2003).

Road Density

Road density for Sund Creek is 2.94 miles of road per square mile of watershed. Road density for Miller Creek is 4.08 miles of road per square mile of watershed (PNPTC, unpublished data, 2003a).

Riparian Zones

Riparian Condition

Riparian condition is poor in the anadromous reach but good upstream (TAG 2003).

Water Quality

Temperature

Temperature data has not been collected/analyzed.

Dissolved Oxygen

Dissolved oxygen is a data gap.

Hydrology

Flow: Hydrologic Maturity

For Sund and Miller creeks combined, 10% of the watershed is hydrologically immature, 0% is intermediate maturity and 90% is hydrologically mature. Combining the two watersheds, 11% of the forested area is between 4 and 40 years old (USFS 1997). WDNR reports 71% of their lands in the Sund Creek watershed is hydrologically mature and 78% of their lands in the Miller Creek watershed is hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface

Percent impervious surface is unknown.

Biological Processes

Nutrients (Carcasses)

Escapement has not been determined for these watersheds. Small numbers of fall chum (in the vicinity of 200) and an occasional coho utilize the lower 0.3 miles of Miller Creek as indicated by WDFW spawner surveys. Similar numbers are observed in the lower 0.2 miles of Sund Creek (WDFW, spawning ground data, 1999).

Estuaries

A parking lot has replaced a historic salt marsh on Sund Creek estuary and a dive shop was built on historic outcroppings but extends out into the intertidal area. Both should be moved away from the shoreline. The mouth of Miller Creek has lost approximately 3.4 acres of salt marsh due to development (TAG 2003).

Data Needs

- Determine fine sediments
- Collect pool data

Action Recommendations

- Restore estuary/nearshore function
  - Remove parking lot fill and relocate parking lot away from shoreline
  - Relocate dive shop away from intertidal
- Restore channel complexity
  - Add large woody debris
  - Remove riprap/diking where possible and restore sinuosity
- Replant riparian zone with native species

Clark Creek

Clark Creek is 1.4 miles long and enters Hood Canal to the south of Miller Creek and north of Hoodsport. Terrain is rather rugged and land use has been limited to logging in the upper watershed and residential development along the shoreline of Hood Canal. It is unknown if fish can navigate upstream of the cascade at river mile 0.2. The gradient is less steep in the lower watershed where small populations of coho and chum spawn (Williams et al. 1975). There are approximately 869 acres in the Clark Creek watershed with only 1% in WDNR ownership (Carol Thayer, unpublished data, 2003).

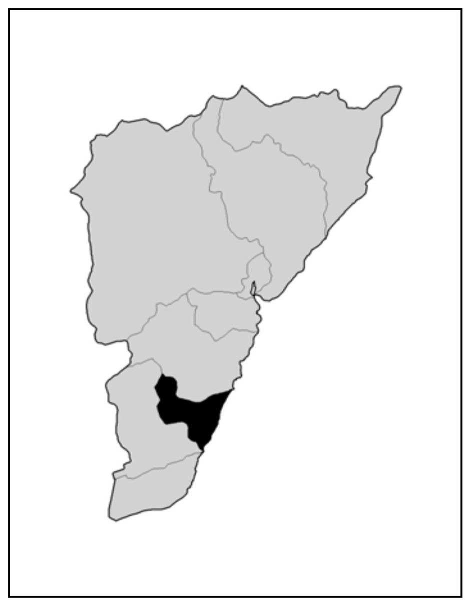

Figure 52. Clark Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

The culvert at Highway 101 is undersized and should be replaced with a bridge.

Floodplains

Floodplain Connectivity

The creek has been channelized and dredged in the lower reach and flows subsurface in the summer months (TAG 2003). The upstream resident trout reaches have perennial flow (Marty Ereth, personal communication, 2003).

Loss of Floodplain Habitat

Highway 101 constricts estuary and stream function (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Large wood is sparse in the lower watershed.

Percent Pool/Pool Frequency/Pool Quality

Pool information is a data gap.

Streambank Stability

There is no major erosion in the lower watershed.

Sediment Input

Sediment Supply

Coarse sediment is abundant within the transport reach. The source is unknown. The lower reach is dredged annually due to the constriction at the mouth (Highway 101). Whether the amount of sediment is above natural levels is unknown (TAG 2003).

Mass Wasting

Mass wasting events are unknown. Soil mass wasting potential on WDNR lands shows it all to be within insignificant potential (Carol Thayer, unpublished data, 2003).

Road Density

Road density is unknown.

Riparian Zones

Riparian Condition

The riparian zone consists of young tees in the lower reach and more mature trees in the upper reach (TAG 2003).

Water Quality

Temperature/Dissolved Oxygen
Water quality is unknown.

Hydrology

Flow: Hydrologic Maturity
Hydrologic maturity is unknown. WDNR reports that 33% of their lands are hydrologically mature (Carol Thayer, unpublished data, 2003).

Flow: Percent Impervious Surface
Percent impervious surface is unknown.

Biological Processes

Nutrients (Carcasses)
Nutrients are unknown. However, small numbers of fall chum and juvenile coho have been observed in Clark Creek within the last few years by Skokomish tribal fisheries staff (Marty Ereth, personal communication, 2003).

Data Needs

- Determine fine sediments
- Assess pool habitat
- Determine mass wasting
- Determine road densities and assess road impacts on aquatic resources
- Collect water quality data
- Determine hydrologic maturity
- Calculate percent impervious surface

Action Recommendations

- Restore estuary function
    - Replace Highway 101 culvert with a bridge
- Restore channel complexity
    - Add large woody debris

Finch Creek

Finch Creek is 3.3 miles long with anadromous access to a natural barrier cascade at river mile 1.3 (Williams et al. 1975). There are approximately 2,272 acres in the watershed with 15% in WDNR ownership (Carol Thayer, unpublished data, 2003).

Access and Passage

Artificial Barriers
A hatchery intake structure is a complete barrier to fish migration at river mile 0.3. An additional 1.0 to 1.5 miles of habitat would be available for spawning and rearing salmonids (TAG 2002).

Figure 53. Finch Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity
There are seeps and springs along the left bank but the armored banks prevent connectivity (TAG 2003).

Loss of Floodplain Habitat
Development within the floodplain constricts the channel and contributes to habitat loss (TAG 2003).

Channel Condition

Fine Sediment
This parameter is a data gap.

Large Woody Debris
Large wood is scarce in the lower watershed (TAG 2003). Of the 533 acres in riparian area, 47% has poor potential for large woody debris recruitment, 52% fair and 0% good (USFS 1997).

Percent Pool/Pool Frequency/Pool Quality
Pools have not been assessed.

Streambank Stability
The streambanks in the lower floodplain are armored, which sometimes indicates instability. Actively eroding banks are observed within steeper gradient areas upstream (TAG 2003).

Sediment Input

Sediment Supply
There are ample quantities of coarse sediment and spawning gravels (TAG 2003).

Mass Wasting
Mass wasting potential is 99% low hazard and 1% high hazard with 15% of the watershed containing steep, generally erosive soils. Rain-on-snow affects only 0.6% of the watershed (USFS 1997). WDNR reports that 33% of their lands indicate insignificant soil mass wasting potential, 5% low potential, 44% moderate potential and 17% high potential (Carol Thayer, unpublished data, 2003).

Road Density

Road density is 5.59 miles of road per square mile of watershed. The majority of the roads are clustered within the town of Hoodsport (PNPTC, unpublished data, 2003).

Riparian Zones

Riparian Condition

Of the 533 acres in riparian area, 47% has poor potential for large woody debris recruitment, 52% fair and 0% good (USFS 1997).

Water Quality

Temperature

Temperature is unknown

Dissolved Oxygen

Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity

Approximately 22% of the watershed is hydrologically immature while 78% is hydrologically mature (USFS 1997). WDNR reports that 60% of their ownership is hydrologically mature (Carol Thayer, unpublished data, 2003). Ninety-five percent of the watershed is forested. Of that 95%, 19% of the coniferous stands is less than 10 years old, 18.8% is between 10 and 50 years, and 46.5% is between 50 and 160 years with no part of the forest older than 160 years. Approximately 15.5% of the deciduous forest acreage is older than 50 years (PSCRBT 1995).

Flow: Percent Impervious Surface

Developed impervious surface is 1.7% (PSCRBT 1995).

Biological Processes

Nutrients (Carcasses)

Due to no escapement past the artificial barrier at river mile 0.3, nutrient values are probably low.

Estuaries

The historic bell-shaped estuary has been filled at the mouth of Finch Creek and channelized into a cement flume. Hoodsport Hatchery intrudes onto the intertidal area and eliminates a safe shallow water migration corridor (TAG 2003).

Data Needs

- Collect pool data

Action Recommendations

- Restore estuary function
  - Remove fill along right bank of estuary
  - If/when possible, relocate fish hatchery away from shoreline
- Provide fish passage beyond the hatchery and its intake
- Restore complexity in the lower watershed

Hill Creek

Figure 54. Hill Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Hill Creek is one mile long with water supply from apparent spring sources (Williams et al. 1975). The upper ½ mile of Hill Creek is seasonal. Flows are spring fed and emerge near the bottom of a small canyon (Marty Ereth, personal communication, 2003). A 20-foot high dam blocks anadromous fish migration approximately 200 meters from the mouth of the stream. Fall chum, coho, pinks, chinook and cutthroat have been observed in the lower watershed, but gravel recruitment is low and consequently production is limited (Jeff Heinis, personal communication, 2003).

Access and Passage

Artificial Barriers

A dam downstream of a trout pond eliminates fish passage upstream (TAG 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

The lower watershed is confined and greater than 1% gradient. This parameter is therefore not applicable.

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Large woody debris is fairly abundant in the seasonal canyon reach in the form of windfalls but is primarily small in size (Marty Ereth, personal communication, 2003). Large wood is sparse in the anadromous reach (Jeff Heinis, personal communication, 2003).

Percent Pool/Pool Frequency/Pool Quality

Pool information is a data gap.

Streambank Stability

Streambanks appear to be stable (TAG 2003).

Sediment Input

Sediment Supply

The intermittent reach in the canyon appears flashy as the channel is 3-8 meters wide and the substrate is primarily coarse cobble. The flashy nature of the upper channel does not appear to be exhibited in the lower channel. The dam at the trout farm, approximately 200 meters upstream of the mouth, restricts debris and sediment transport to the lower reach (TAG 2003). The streambed in the lower reach is largely clay (Jeff Heinis, personal communication, 2003).

Mass Wasting

Mass wasting is unknown.

Road Density

Road density is 5.12 miles of road per square mile of watershed, including all the independent tributaries to Hood Canal within the Potlatch area (PNPTC, unpublished data, 2003).

Riparian Zones

Riparian Condition

The riparian zone has good canopy closure, particularly along the south side (TAG 2003).

Water Quality

Temperature/Dissolved Oxygen

Water quality is unknown.

Hydrology

Flow: Hydrologic Maturity

Hydrologic maturity is unknown.

Flow: Percent Impervious Surface
Percent impervious surface is unknown.

Biological Processes

Nutrients (Carcasses)
Nutrients are unknown, but expected to be low due to limited fish production (TAG 2003).

Data Needs

- Collect pool information
- Assess fine sediments
- Determine mass wasting
- Calculate percent impervious surface

Action Recommendations

- Remove dam associated with old trout farm
- Restore complexity, i.e. large wood

SKOKOMISH SUB-BASIN

The Skokomish watershed, located in the northern part of Mason County, lies to the south of the Lilliwaup watershed in the southern portion of WRIA 16. The Skokomish sub-basin includes four independent tributaries to Hood Canal to the north of the Skokomish delta: an unnamed creek entering Hood Canal near the Canal Side Diner (WRIA 16.0220), Minerva Creek (WRIA 16.0218), Potlatch State Park Creek (WRIA 16.0218a), and Enetai Creek (16.0217). The mainstem Skokomish (WRIA 16.0001) extends approximately 9 miles to the confluence with the South Fork (WRIA 16.0011) and continues an additional 33 miles up the North Fork. The South Fork extends 27.5 miles. Tributaries to the mainstem include Purdy Creek (WRIA 16.0005) and its main tributary Weaver Creek (WRIA 16.006), Hunter Creek (WRIA 16.0007) and Richert Springs (WRIA 16.0009). The main tributary to the North Fork is McTaggert Creek (WRIA 16.0105). Tributaries to the South Fork include Vance Creek (WRIA 16.0013), Flat/Rock Creek (WRIA 16.0037/16.0038), Brown Creek (WRIA 16.0047, LeBar Creek (WRIA 16.0053), Cedar Creek (WRIA 16.0066), Pine Creek (WRIA 16.0071), and Church Creek (WRIA 16.0077). The following reaches were evaluated by the TAG:

- Unnamed (Canal Side Diner) Creek
- Minerva Creek
- Potlatch Creek
- Enetai Creek
- Skokomish River, mainstem to river mile 9.0
- Purdy Creek, right bank tributary to the mainstem at river mile 3.6
- Weaver Creek, right bank tributary to the mainstem at river mile 4.1
- Hunter Creek, right bank tributary to the mainstem at river mile 6.3
- Richert springs, left bank tributary to the mainstem at river mile 8.0
- North Fork Skokomish, mouth to Kokanee Dam
- North Fork Skokomish, above Kokanee Dam
- McTaggert Creek, right bank tributary to the North Fork at river mile 13.3
- South Fork Skokomish, mouth to river mile 3.0
- South Fork Skokomish, river mile 3.0 to river mile 10.0 (canyon)
- South Fork Skokomish, river mile 10.0 to falls at river mile 23.5
- South Fork Skokomish, above the falls at river mile 23.5
- Vance Creek, right bank tributary to the South Fork at river mile 0.8
- Rock Creek, left bank tributary to Flat Creek (enters SF at river mile 8.7)
- Brown Creek, left bank tributary to the South Fork at river mile 12.8
- LeBar Creek, left bank tributary to the South Fork at river mile 13.5
- Cedar Creek, right bank tributary to the South Fork at river mile 17.9
- Pine Creek, right bank tributary to the South Fork at river mile 19.2
- Church Creek, right bank tributary to the South Fork at river mile 21.4

Unnamed (Canal Side Diner) Creek

The unnamed tributary that enters Hood Canal just to the north of the Tacoma Public Utility power house near the existing Canal Side Diner is approximately 1.35 miles long (Williams et al. 1975). Fish have access through the SR101 culvert at approximately river mile 0.15, but cannot pass through the culvert immediately upstream at the parking lot and associated stormwater vault of the Tacoma Public Utility power house. Approximately 1.2 miles are inaccessible but the spring fed forested wetland complex is capable of providing good fish habitat. There is limited spawning below SR101 (Marty Ereth, personal communication, 2003). Cutthroat are presumed to inhabit the upper portion of the system (TAG 2002). Quantitative data have not been collected for this system.

Figure 55. Unnamed Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Action Recommendations

- Remediate culvert at SR101 for better passage and at the TPU parking lot, which is a total barrier
- Restore channel sinuosity in place of the TPU parking lot
- Restore channel downstream of SR101
- Improve stormwater control from TPU parking lot.

Minerva Creek

Minerva Creek, approximately 1.4 miles long (Williams et al. 1975), enters Hood Canal to the south of the Tacoma Public Utilities picnic area/boat launch. Cutthroat are known to inhabit the lower reach and are presumed in the upper reach (TAG 2002). The lower part of the creek flows under a residential development and should be day-lighted. SR101 is a passage barrier as is the culvert at Harvey Terrace Drive (Marty Ereth, personal communication, 2003). The floodplain is confined and the estuary no longer exists. Quantitative data do not exist for this system.

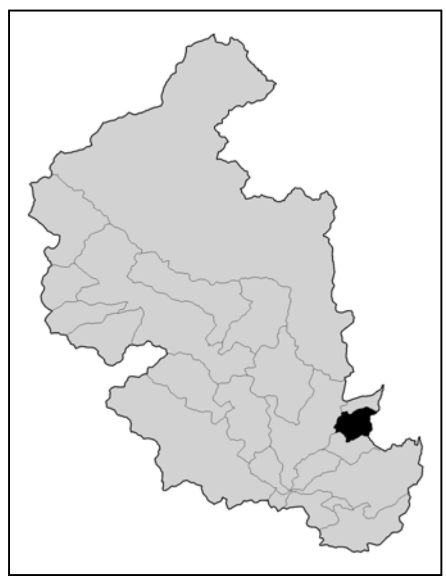

Figure 56. Minerva and Potlatch Watershed. Map provided by Jennifer Cutler, NWIFC.

Action Recommendations

- Provide passage at SR101
- Provide passage at Longshore Drive-In

Potlatch Creek

Potlatch Creek, meaning "heaven" in the Twana language is approximately 0.3 to 0.5 mile long, runs through Potlatch State Park and is occasionally utilized by chum in the lower reach and cutthroat both upstream and downstream of SR101. The stream source is a spring-fed forested wetland. Four culverts, 6 to 8 feet apart and including SR101, are in the lower watershed. Two are above the highway and one is below. SR101 is a barrier and there is a barrier at the mouth where water flows through an asphalt flume and drops 6 feet at low tide. The campground is the site of an old pulp mill and much of the shoreline is built on wood waste, which is now eroding. The historic salt marsh with tide channels has been replaced with park lawns and picnic areas (TAG 2003). Quantitative data have not been collected for this system.

Action Recommendations

- Restore floodplain
- Assess feasibility of creating a new channel mouth through the forest and implement if appropriate

Enetai Creek

A tribal fish hatchery sits near the mouth of Enetai Creek, approximately 1.7 miles long (Williams et al. 1975). The historic tidal channel extended upstream to the hatchery, which now restricts tidal action due to a concrete vault. The hatchery intake is upstream of an earthen dam which is a total barrier to fish migration. Habitat upstream of the dam is in good shape. Chum, coho, chinook and cutthroat are found in the lower system and resident trout are found above the dam (TAG 2003).

Action Recommendations

- Provide fish passage upstream of the hatchery intake

Figure 57. Enetai Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Skokomish River

The Skokomish River is the largest river system draining into Hood Canal with a watershed area of approximately 240 square miles comprised of 80 miles of mainstem and over 260 miles of tributaries (WDFW and PNPTT 2000). The lower Skokomish River, also referred to as the mainstem, flows for 9.0 miles between the mouth and the forks. The North Fork Skokomish is the continuance of the mainstem, while the South

Fork becomes a tributary, the largest at approximately 27.5 miles in length. The South Fork originates in the Capitol Peak region of the southern Olympic Range and drains generally southeast for more than 20 miles through mountainous terrain. The North Fork originates in the Mount Skokomish-Mount Stone vicinity and circles first west-northwest nearly three miles, southwest more than 5 miles, then southeast about 5 miles to the Cushman Reservoir at river mile 28.0. The lower South Fork, Vance Creek (tributary to the lower South Fork) and the mainstem drain a broad fertile, valley with rural home/hobby farm development (Williams et al. 1975). The Skokomish River enters the southwest end of Hood Canal known as the Great Bend between the rural towns of Potlatch and Union, creating the largest subestuary and intertidal delta in the Hood Canal Basin (WDFW and PNPTT 2000).

Historically the Skokomish River system produced the largest runs of salmon and steelhead in Hood Canal, most of which were produced in the North Fork. The watershed has been managed primarily for hydropower production, timber and agriculture. The North Fork has suffered from severely reduced flows, the South Fork has experienced extensive timber harvest and the mainstem has been channelized with levees to reduce flooding. Aggradation is a serious condition resulting from these land use activities. Past logging practices in the South Fork, including road failures, have increased the sediment supply much beyond natural levels. The lack of flows in the North Fork have reduced sediment transport capabilities. Channelization and diking further contribute to sediment accumulation. The resulting habitat conditions overall are poor due to water diversions, estuary modifications, low channel complexity, extensive diking, sediment accumulation, peak flows, poor riparian conditions and water quality degradation (WDFW and PNPTT 2000).

Skokomish River Mainstem, Mouth to Forks at River Mile 9.0

The lower Skokomish River, also referred to as the mainstem, flows for 9.0 miles between the mouth and the forks, primarily through a broad valley of rural hobby farms, rural residential development and agriculture. Six tributaries contribute and additional 11.3 miles (WDFW and PNPTT 2000). This drainage segment encompasses approximately 17.9 square miles. Drainage density is 3.51 river miles per square mile of watershed (USFS 1995). The lower 5.9 miles of the river, including a substantial portion of the subestuary, are located on the Skokomish Indian Reservation (WDFW and PNPTT 2000).

Figure 58. Skokomish Watershed, RM 0.0-9.0. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers to fish migration in the 9.0 miles of the mainstem. There is a hydrologic barrier in the late summer/early fall due to aggradation. Skokomish Valley Road is an artificial barrier during high flows when fish become stranded in the overflow channels (TAG 2003). A velocity barrier exists on Skobob Creek, a left bank tributary near the estuary, under SR106. Skobob Creek joins the top of the tidally affected Nalley Slough. Tides affect Skobob Creek upstream of the Tribal Center Road but below the SR106 culvert. The barrier under SR106 is a box concrete culvert that spans only a portion of the original wetland channel outlet. The crossing is scheduled to be replaced with a 120-foot bridge span during the summer of 2003 or 2004 (Marty Ereth, personal communication, 2003).

Floodplains

Floodplain Connectivity

Historically, the Skokomish valley floodplain contained numerous sloughs, side channels and forested wetlands. Today, the majority of the mainstem has been diked and/or channelized which has eliminated access to important side channels and wetland habitats.

Loss of Floodplain Habitat

The majority of the mainstem has been channelized, armored and/or diked, greatly reducing channel complexity, stability and sinuosity. Sparse riparian corridors remain throughout the valley. The streambed is aggrading due to the reduced transport capability from water withdrawal, accelerated sediment supply from logging activities and channelization and levee construction. Diking restricts flooding flows from distributing sediments onto the floodplain, which exacerbates the aggradation and leads to further the dredging/diking/aggradation cycle. There has been a modest amount of habitat gain in terms of wetland creation since the water table has risen (Marty Ereth, personal communication, 2003). SR101 and SR106 bridges restrict channel migration.

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

TFW ambient monitoring data has not been collected for this reach; however, observations during a 1998 float trip indicate a scarcity of wood, particularly large wood and log jams (WDFW and PNPTT 2000). In the late 1800s and early 1900s large woody debris and logjams were removed from the South Fork and the mainstem Skokomish in an attempt to prevent flooding and to facilitate log transport to the marine waters. One report documents a jam 3 miles thick formed over a 50 year period that took 18 months to remove using dynamite, horse teams and steam donkeys (Richert 1964, cited in WDFW and PNPTT 2000). Wood salvage and channel manipulation continue to the present.

Percent Pool

TFW ambient monitoring data has not been collected for this reach but observations during a 1998 float trip upstream of river mile 4 indicate a general lack of pools (WDFW and PNPTT 2000).

Pool Frequency

A 1998 float trip through the upper 5 miles of this reach indicates a general lack of pools (WDFW and PNPTT 2000).

Pool Quality

Pool quality is unknown.

Streambank Stability

There is some instability in places but it does not appear to be a real problem.

Sediment Input

Sediment Supply

Past timber harvest practices in the Vance Creek and South Fork watersheds have increased sediment aggradation in the deposition reaches and the mainstem as a result of mass wasting and road failures. Aggradation has reduced the conveyance capacity of the mainstem from the pre-dam level of 18,000 cfs to roughly 5,000cfs (Stetsons 1996, cited in WDFW and PNPTT 2000). Aggradation has been estimated by numerous entities to range from 3.0 to 4.5 feet (USDI 1997, cited in WDFW and PNPTT 2000).

Mass Wasting

This parameter is not applicable due to the lack of slopes within the valley.

Road Density

Approximately 55 miles of road are within this watershed segment, which leads to road density at 3.08 miles of road per square mile of watershed. In addition, there are 101 river crossings (USFS 1995). The number of road miles is a conservative estimate (TAG 2003).

Riparian Zones

Riparian Condition

In the late 1800s and early 1900s, thick old growth stands were cleared for farming, timber extraction and perceived flood protection (Richert 1964, in WDFW and PNPTT 2000). Although there are pockets of good riparian, approximately 62% of the mainstem is sparsely vegetated, has been cleared for agriculture, has a riparian buffer of less than 66 feet in width and does not provide for large woody debris recruitment that is necessary to maintain structurally diverse channels (WDFW and PNPTT 2000).

Water Quality

Temperature

Temperature data was collected by Washington Department of Ecology during the mid to late 1990s but was not readily available for this report. Reaches monitored included the lower South Fork Skokomish below the gage, the canyon reach below the Steel Bridge at the bottom of the West Lake Trail and at the Oxbow Campground above the canyon and Holman Flats (Marty Ereth, personal communication, 2003).

Dissolved Oxygen

Dissolved oxygen is a data gap.

Hydrology

Reduced annual flows in the North Fork, resulting from hydropower diversion and production, has reduced mainstem flows by about 40%, impacting habitat conditions in the North Fork, mainstem Skokomish River, subestuary and intertidal delta. The diversion reduces flow in the North Fork, but also contributes to channel aggradation by robbing the valley of some sediment-flushing flows. The US Environmental Protection Agency, National Marine Fisheries Service and the US Department of Interior agree that restoring to 84% natural flow is the minimum protection required for aquatic resources for the North Fork and mainstem Skokomish River and subestuary/delta (WDFW and PNPTT 2000).

Flow: Hydrologic Maturity

Approximately 61.4% of the watershed is hydrologically immature, 5% is of intermediate maturity and 33.6% is mature (USFS 1995).

Flow: Percent Impervious Surface

Impervious surface for this segment is a data gap. However, Mason County Public Works has estimated the miles of paved road within the entire Skokomish watershed to be 11.14 linear miles. Road widths range from 18-22 feet (Denise Forbes (personal communication, 2003).

Biological Processes

Nutrients (Carcasses)

Chinook and summer chum are federally listed as threatened and it is believed that summer chum have been extirpated from the system. Winter steelhead are listed as depressed, upper late fall chum and coho are healthy and lower fall chum and summer steelhead are unknown (SaSI 2003). Based on the number of threatened and depressed stocks, nutrients in the mainstem Skokomish are low.

Estuaries

The historic Skokomish Delta encompassed 2,175 acres with a perimeter of 11.2 miles. Approximately 313 acres (14.4%) has been diked for agriculture, although a recent breach in the largest contiguous dike at the old Nalley farm has allowed tidal inundation of this area. Dikes and several tidegates have isolated historic salt marsh habitat which have been maintained as wetlands. In addition, thirteen roads/causeways totaling 4.7 miles in length cross or encompass the delta and are used as access to the dikes/agriculture lands and/or maintenance of the transmission towers. The transmission tower service roads impact a long segment of the upper intertidal habitat, restricting tidal movement and juvenile foraging activity (WDFW and PNPTT 2000). The largest long-term impact to the delta has been identified as the steepening of the delta and subsequent loss of approximately 17% of the eelgrass habitat, which is critical for juvenile salmonids (Jay and Simenstad 1996, cited in WDFW and PNPTT 2000). This dramatic change is primarily attributed to the loss of sediment transport through the delta due to water withdrawals (WDFW and PNPTT 2000).

Data Needs

- Collect and/or analyze water quality data

Mainstem Action Recommendations

- Conduct river reach analysis for habitat regarding channel reconstruction, complexity restoration, floodplain acquisition, and levee removal
- Restore floodplain connectivity
  - Remove or set back all levees and dikes
    - In the vicinity of the forks on the north and south side
    - Downstream of SR101 on the south side of the river
    - Downstream of SR106 on the south side of the river
    - Others
  - Culvert dikes to allow flow through to overflow channels
  - Remove the majority of River Road
  - Provide capacity to pass 100 year storm events and associated debris at SR101, such as an elevated roadway
  - Replace Skobob culvert with a bridge to pass 100 year flows and debris
- Restore habitat complexity and sinuosity
  - Leave existing wood in the system
  - Construct engineered logjams
- Assess the need for three fish hatcheries within the Skokomish watershed

Purdy Creek

Purdy Creek is a stable spring-fed, right bank tributary that flows through an extensive wetland system prior to entering the mainstem Skokomish at river mile 3.6 (WDFW and PNPTT 2000). The watershed area is approximately 3,866 acres or 6 square miles (USFS 1995). An impassable falls at river mile 1.8 restricts anadromous migration from the remaining 2.35 miles. Purdy Creek joins with Weaver Creek in a wetland complex but each has a separate confluence with the mainstem Skokomish River. Ten-acre Creek, originating in nice headwater wetlands, is a tributary to Purdy Creek and is ditched and drained on the north side. The WDFW George Adams Hatchery is located at river mile

1.0 and successfully produces large numbers of chinook, chum and coho (Williams et al. 1975).

Access and Passage

Artificial Barriers

George Adams Hatchery maintains an instream adult trap and an intake structure that are barriers to fish migration. A culvert has been replaced on an unnamed right bank tributary to lower Purdy Creek, but it is severely headcutting and is impassable to chum, although coho fry have been observed upstream (Marty Ereth, personal communication, 2003).

Figure 59. Purdy Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity

The lower mile of Purdy Creek flows through a large intact wetland system, which is interrupted by SR101 and the WDFW George Adams Fish Hatchery. Historically, summer chum spawned at the hatchery site (TAG 2003).

Loss of Floodplain Habitat

The lower mile of Purdy Creek flows through a large, intact forested wetland system that is now confined by roads (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large woody debris is plentiful throughout the wetland and upstream of the hatchery. There is no wood near the hatchery or in the ditched areas (Marty Ereth, personal communication, 2003).

Percent Pool

Percent pool is a data gap but TAG observations indicate that pools are good in the wetland system but poor in the ditches.

Pool Frequency

Pool frequency is a data gap.

Pool Quality

Pool quality is a data gap.

Streambank Stability

Some streambank instability has been observed along steep slopes with shallow soils (TAG 2003).

Sediment Input

Sediment Supply

Gravels exist primarily upstream of the George Adams Hatchery in Purdy Creek and in the headwaters of Ten Acre Creek that drain the southern valley wall (Marty Ereth, personal communication, 2003).

Mass Wasting

Within the forest cover 3% is less than 35 years of age, 3% of the soils are steep and erosive and the mass wasting potential is 22% low hazard (USFS 1995). Mass wasting events in Purdy Creek have been of a very small magnitude (TAG 2003).

Road Density

Approximately 25.3 miles of road extend throughout the Purdy Creek watershed, yielding a road density of 4.19 miles of road per square mile of watershed. In addition, there are 12 stream crossings in this watershed (USFS 1995).

Riparian Zones

Riparian Condition

The lower mile of Purdy Creek flows through a large, intact, forested wetland system. Riparian condition in the upper watershed is not as good. Upstream of the hatchery, SR101 borders the right bank and deciduous trees on unstable slopes border on the right bank (TAG 2003).

Water Quality

Temperature

George Adams Hatchery has collected the following water temperatures to ensure fish health and to determine development rates during the egg to fry stages. Water temperatures from this spring-fed system have remained cool year round since 1992, with the exception of July 2000 when they exceeded $14^{o}C$ (Ed Jouper, unpublished data, 2003).

Dissolved Oxygen

Dissolved oxygen is a data gap.

Hydrology

Flow: Hydrologic Maturity

Approximately 52.5% of the watershed is hydrologically immature while 7.8% is of intermediate maturity and 39.7% is mature (USFS 1995).

Flow: Percent Impervious Surface

Percent impervious surface is low in this watershed (TAG 2003).

Biological Processes

Nutrients (Carcasses)

Nutrient value within Purdy Creek has not been established.

Action Recommendations

- Restore fish passage, within Ten-acre Creek: one at George Adams Hatchery, two undersized culverts upstream of the hatchery on Skokomish Valley Road and a driveway culvert on the ditched section
- Assess potential to restore anadromous access upstream of the George Adams Hatchery
- Assess, and implement if feasible, the potential for removing the hatchery road along Ten-acre Creek
- Remove East Bourgault Road and the bridge over Purdy Creek that is no longer necessary

Weaver Creek

Weaver Creek, a spring-fed, right bank tributary the mainstem at river mile 4.1, extends 1.3 miles through agricultural lands in the southern portion of the Skokomish floodplain (WDFW and PNPTT 2000). The cold clear spring water makes Weaver Creek favorable for a small WDFW fish hatchery but also has spawning populations of chum and coho (Williams et al. 1975).

Figure 60. Weaver Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers on Weaver Creek until the upper watershed where the adult trap at McKernon Hatchery blocks anadromous migration upstream. The habitat upstream is a wetland complex which is limited in spawning habitat (Steve Smotherman, personal communication, 2003) but rich in rearing habitat (Marty Ereth, personal communication, 2003).

Floodplains

Floodplain Connectivity

Weaver Creek is incised and therefore has no access to the floodplain. It is periodically dredged yet there are no berms along the banks.

Loss of Floodplain Habitat

The Weaver Creek floodplain has been altered significantly for agriculture purposes. Historically there was a lot of wood within the system with diverse habitats. It is now a log gradient flowing pool that is periodically dredged. The headwaters remain forested wetlands

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Historically there was a lot of wood in the system, which created pools and diverse habitats. Large wood is lacking today and future recruitment is poor.

Percent Pool

Weaver Creek is now a long flowing pool that is dredged periodically and does not provide typical pool qualities for juvenile fish (TAG 2003).

Pool Frequency

Although quantitative data is lacking for pools on Weaver Creek, collective experience of TAG members acknowledges that the creek is a long flowing pool that is dredged periodically.

Pool Quality

Pool quality is poor (TAG 2003).

Streambank Stability

Streambank stability is a data gap.

Sediment Input

Sediment Supply

Sediment supply is a data gap.

Mass Wasting

Mass wasting is not applicable in this watershed due to the lack of steep slopes (TAG 2003).

Road Density

Even though road densities have not been calculated for this watershed, it is well known that there are numerous roads within the floodplain (TAG 2003).

Riparian Zones

Riparian Condition

Approximately 57% of Weaver Creek is sparsely vegetated, has been converted to agriculture, and/or has a riparian buffer less than 66 feet in width (WDFW and PNPTT 2000). The Mason county Conservation District has replanted approximately two acres with good survival (Marty Ereth, personal communication, 2003).

Water Quality

Temperature

Water temperatures taken near the headwaters at McKernon Hatchery range between 5.6^{o}C and 13^{o}C, with a rare spike to 15.0^{o}C (Steve Smotherman, personal communication, 2003). There are hyporheic upwellings throughout the system (Marty Ereth, personal communication, 2003).

Dissolved Oxygen

Dissolved oxygen is a data gap although algae blooms have been observed occasionally TAG 2003).

Hydrology

Flow: Hydrologic Maturity

Hydrologic maturity is poor in this watershed as the forests have been cleared for agriculture (TAG 2003).

Flow: Percent Impervious Surface

Paved roads are minimal in this watershed (TAG 2003).

Biological Processes

Nutrients (Carcasses)

Nutrients are a data gap.

Data Needs

- Determine fish populations

Action Recommendations

- Place conservation easements along the riparian corridor and reestablish riparian zone
- Restore channel complexity
- Protect headwater forests and wetlands
- Assess potential to restore access to wetlands upstream of McKernon Hatchery

Hunter Creek

Hunter Creek, a spring-fed, right bank tributary to the mainstem at river mile 6.3, flows approximately 3.0 to 3.5 miles through the agricultural lands along the southern part of the Skokomish River Valley. The cool, clean spring water is favorable to a small WDFW trout hatchery, but spawning populations of chinook, coho, steelhead and chum have also been observed (TAG 2002). Approximately 81% of Hunter Creek has been converted to agriculture, is sparsely vegetated and/or has a forested riparian buffer of less than 66 feet in width (WDFW and PNPTT 2000).

Figure 61. Hunter Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

It should be noted that the dam/intake structure for Eel Springs hatchery is on Swift Creek, an independent tributary to the South Fork Skokomish River that was once the historic Vance Creek channel. It has not experienced agriculture conversion and is replete with beaver dams and a forested riparian zone (TAG 2003)

Access and Passage

Artificial Barriers

There are no known migration barriers to salmon between the mouth and the headwaters at the WDFW hatchery at Eel Springs. Fish are not passed upstream of the facility (Dan Atkins, personal communication, 2003).

Floodplains

Floodplain Connectivity

The floodplain is incised in the lower section, which limits access to the floodplain. There are no dikes in this system although there is armoring along the hatchery road. The channel is periodically dredged for maintenance (TAG 2003).

Loss of Floodplain Habitat

The floodplain has been converted to agriculture and lacks a riparian zone and consequently lacks large woody debris recruitment (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large woody debris is lacking in the system and future recruitment is poor (TAG 2003).

Percent Pool

Although pool data has not been collected, the TAG agrees that the channel is one long, slow-moving pool, which does not contain the diversity favorable to juvenile rearing (TAG 2003).

Pool Frequency

Although pool data has not been collected, the TAG agrees that the channel is one long, slow-moving pool, which does not contain the diversity favorable to juvenile rearing (TAG 2003).

Pool Quality

Although pool data has not been collected, the TAG agrees that the channel is one long, slow-moving pool, which does not contain the diversity favorable to juvenile rearing (TAG 2003).

Streambank Stability

Streambank stability is unknown.

Sediment Input

Sediment Supply

There are pockets of gravel throughout the system (TAG 2003).

Mass Wasting

Mass wasting is not an issue in this watershed (TAG 2003).

Road Density

Although there are no road density calculations, the TAG agrees that there are numerous roads throughout the floodplain.

Riparian Zones

Riparian Condition

The majority of the riparian zone has been cleared for agriculture (TAG 2003). The lower reach downstream of the Skokomish Valley Road still has riparian habitat, albeit mostly hardwoods and blackberries (Marty Ereth, personal communication, 2003).

Water Quality

Temperature

Temperatures at the Eel Springs Hatchery near the headwaters range consistently between 8.3^{o}C and 9.2^{o}C (Dan Atkins, personal communication, 2003).

Dissolved Oxygen

Dissolved oxygen is a data gap although no algae blooms have been observed within this watershed (TAG 2003).

Hydrology

Flow: Hydrologic Maturity

There are some trees in this floodplain but hydrologic maturity is poor since the majority has been converted to agriculture (TAG 2003).

Flow: Percent Impervious Surface

Percent impervious surface is not an issue in this watershed (TAG 2003).

Biological Processes

Nutrients (Carcasses)

Nutrients are unknown in this watershed.

Action Recommendations

- Restore riparian zone by replanting native species and installing cattle exclusion fencing.
- Restore channel complexity
- Protect headwater forests and wetlands
- Assess potential to restore access to stream channels upstream of the Eel Springs Hatchery intake on Swift Creek

Richert Springs

Richert Springs is a spring-fed system of channels that eventually merge to form a left bank tributary to the mainstem at approximately river mile 8.0 (Williams et al. 1975). Flood flows from the South Fork back up into the North Fork which breech the dike and exit out Richert Springs. In addition, high flows also travel through three extensive dike breaches on the mainstem, into an established wetland and then into Richert Springs. Richert Springs is generally not connected by surface water at low to normal water levels (Marty Ereth, personal communication, 2003).

Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers within Richert Springs (TAG 2003).

Floodplains

Floodplain Connectivity

There are three major well-connected, deep and wide channels with many smaller ones in between (TAG 2003).

Loss of Floodplain Habitat

Good habitat remains as the wetland/channel complex is largely undisturbed (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Large wood is plentiful in Richert Springs and future recruitment is good (TAG 2003).

Percent Pool

Quantitative pool data have not been collected but TAG observations indicate good pool conditions.

Pool Frequency

Quantitative pool data have not been collected but TAG observations indicate good pool conditions.

Pool Quality

Quantitative pool data have not been collected but TAG observations indicate good pool conditions.

Streambank Stability

Streambanks are stable in this system (TAG 2003).

Sediment Input

Sediment Supply
Sediment supply is unknown.

Mass Wasting
Mass wasting is not applicable due to the lack of steep slopes.

Road Density
Road density is a data gap.

Riparian Zones

Riparian Condition
The riparian corridor on Richert Springs is less disturbed than other parts of the Skokomish Valley. Approximately 80% is well vegetated and/or greater than 66 feet in width (WDFW and PNPTT 2000).

Water Quality

Temperature
Temperature data have not been collected.

Dissolved Oxygen
Dissolved oxygen is also a data gap.

Hydrology

Flow: Hydrologic Maturity
The forested areas are of moderate maturity (TAG 2003).

Flow: Percent Impervious Surface
Percent impervious surface is not an issue in this watershed (TAG 2003).

Biological Processes

Nutrients (Carcasses)
Nutrients are unknown.

Action Recommendations

- Protect the watershed through acquisition
- Remove berms and roads
- Place conservation easements on the small parcels to the north for additional watershed protection

North Fork Skokomish

The North Fork Skokomish River originates in the Mount Skokomish-Mount Stone vicinity and circles first west-northwest nearly three miles, southwest more than 5 miles, then southeast about 5 miles to the Cushman Reservoir at river mile 28.0. The entire upper drainage flows through thickly forested mountainous terrain with all but the lower three miles confined to a very narrow steep-sloped valley. Some side hills rise sharply to over 5,000 feet. A narrow channel contains a nearly continuous series of falls and cascades, with a predominantly boulder and rubble stream bottom. The upper watershed, upstream of the reservoir, is almost entirely within the boundaries of Olympic National Park. Cushman Reservoir, a 4,000-acre basin impoundment, continues generally southeast approximately 8.5 miles to the Tacoma Public Utilities upper dam (Williams et al. 1975), which was completed in 1926 and which eliminated the historic 400-acre Lake Cushman and approximately 11.5 miles of river channel and associated floodplain (WDFW and PNPTT 2000). Minimal flows from the reservoir extend 1.5 miles downstream to a second smaller impoundment, Kokanee Reservoir, approximately 100 acres in size. The downstream end of the reservoir, completed in 1930, is located at approximately river mile 17.3 and effectively eliminates anadromous access beyond this point. At one time, all the water from the North Fork was diverted from the reservoirs to the powerhouse on Highway 101 several miles to the north of the natural river mouth. This out-of-basin diversion substantially dewatered 8 miles of the lower North Fork and reduces the flow of the mainstem Skokomish by about 40%. Temporary instream flows have been set at 30 cfs during FERC relicensing hearings but the Tacoma Public Utilities agreed to set them at 60+cfs after a major mudflow inundated the powerhouse. The US Environmental Protection Agency, National Marine Fisheries Service and the US Department of Interior agree that restoring to 84% natural flow is the minimum protection required for aquatic resources for the North Fork and mainstem Skokomish River and subestuary/delta (WDFW and PNPTT 2000).

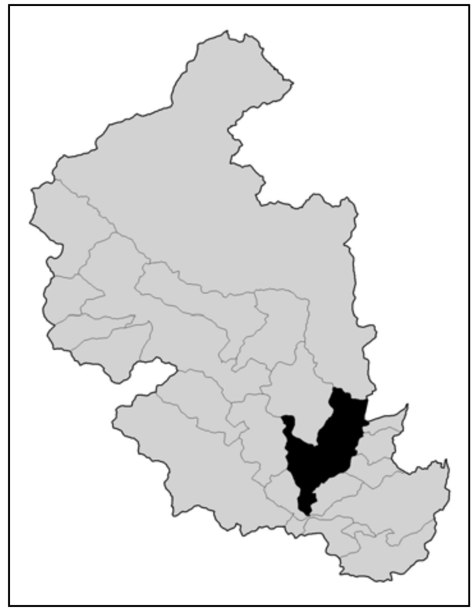

Figure 63. North Fork Skokomish Watershed, RM 10-17.3. Map provided by Jennifer Cutler, NWIFC.

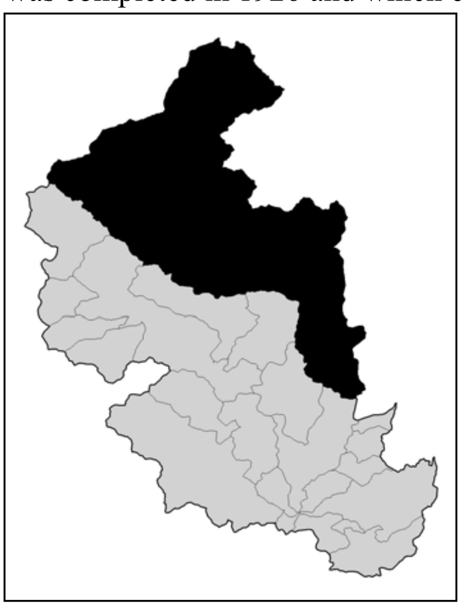

Figure 64. North Fork Skokomish Watershed, above RM 17.3. Map provided by Jennifer Cutler, NWIFC.

The North Fork Skokomish drains a watershed area of approximately 118 square miles (Simpson and WDNR 1997). Less than 20% of the riparian buffer is sparsely vegetated or less than 66 feet in width (WDFW and PNPTT 2000). Recent tree core analysis within Cushman Reservoir and the mainstem upstream have revealed marine derived isotopes (Vick Stan, masters thesis, 2003), which supports the Skokomish Tribal claims that anadromous salmon historically utilized habitats in the North Fork upstream of the existing dams.

Barrier culverts exist on Dow Creek and other unmapped resident fish bearing tributaries to Kokanee Reservoir. Barrier Culverts also exist on tributaries to Big Creek which flows into Cushman Reservoir (Marty Ereth, personal communication, 2003).

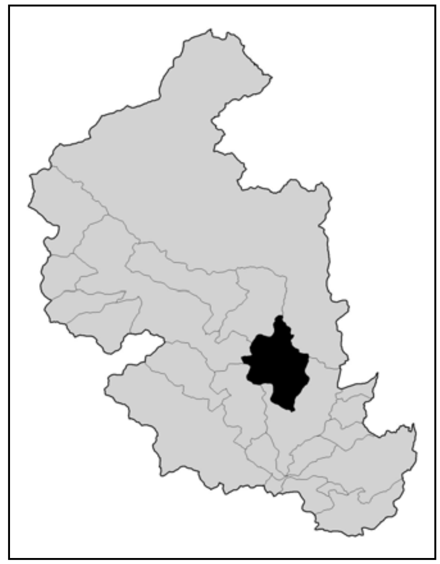

Figure 65. McTaggert Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

McTaggert Creek, a right bank tributary to the North Fork Skokomish at river mile 13.3, extends approximately 5.6 miles with an additional 6.9 miles in tributary habitat (Williams et al. 1975). During the last two enters, coho have ascended upstream to the Cushman Road on McTaggert Creek (approximately river mile 3.8) and upstream into Frigid Creek about ½ mile. The Cushman Road culvert has a vertical drop of about two feet and is undersized. A diversion of the upper portion of McTaggert Creek sends the majority of its flow through Deer Meadow Creek and onward into Kokanee Reservoir. Gibbons Creek, a right bank tributary, joins McTaggert Creek just below a private forest spur road. Gibbons creek is accessible only in the lower 100 meters up to the Cushman mainline culvert, which is a complete barrier. There is about one mile of habitat above this culvert (Marty Ereth, personal communication, 2003).

Due to litigation regarding Federal Energy Regulatory Commission relicense proceedings of the hydropower facilities, this limiting factors analysis does not further discuss salmon habitat conditions on the North Fork or its tributaries.

South Fork Skokomish, Mouth to River Mile 3.0

The South fork Skokomish watershed drains approximately 128 square miles in the southeastern corner of The Olympic Peninsula. Approximately 64% is in US Forest Service ownership (USFS), 28% private, 2% Washington State Department of Natural Resources (WDNR) ands 5% Skokomish Tribal Lands. This analysis separated the South Fork into four segments, based on geomorphology. The USFS watershed analysis combines this segment with the next segment (river mile 0.0 to 12.8); this limiting factors analysis consequently used the combined data when reviewing their report. There are 10.76 square miles in the South Fork between river mile 0.0 and 12.8. There are 37.7 river miles yielding a drainage density of 3.5 miles of stream per square mile of watershed (USFS 1995).

Timber harvest is the primary land use in the upper watershed, which has affected the lower watershed in term of sediment supply

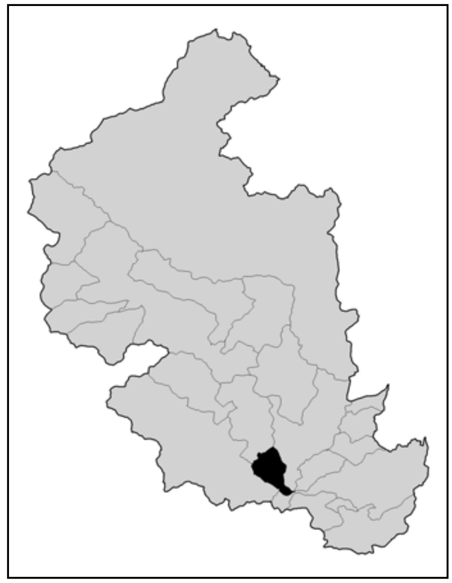

Figure 66. South Fork Skokomish Watershed, RM 0.0-3.0. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known barriers within this segment of the South Fork, although low summer flows through reaches with extensive aggradation and subsurface flows can create hydrologic barriers to adult migration. Immediately upstream of the forks, high flows extend over roads and into fields through overflow channels. When water recedes, fish are stranded (TAG 2002).

Floodplains

Floodplain Connectivity

The majority of this segment that flows through the Skokomish Valley has been channelized, armored and/or diked. Connectivity with off-channel rearing habitats has been eliminated through much of this segment although some existing off channel habitats are still accessible, such as Five Mile Corner Creek. During flood events, high flows from the South Fork enter the North Fork above the confluence then on to Richert Springs. There is a nice wetland complex near the confluence with the North Fork (TAG 2003).

Loss of Floodplain Habitat

While some good habitat still remains, the majority of this segment that flows through Skokomish Valley has been channelized, armored and/or diked, greatly reducing channel complexity, stability and sinuosity. Sparse riparian corridors remain throughout the valley due to agriculture conversion. The streambed is aggrading, partly due to the increased sediment from the South Fork, partly due to reduced transport capability from water withdrawal from the North Fork, and partly due to the channelization and diking. Diking restricts flooding flows from distributing sediments onto the floodplain, which exacerbates the in-channel aggradation and furthers the dredging/diking/aggradation cycle (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is above the natural rate because of the increase in sediment overall. However, there is no instream wood or structure to hold the fine sediment in the system. It is distributed onto the sides when high flows recede or it moves on to the estuary. Fine sediment smothering gravels does not appear to be an issue (TAG 2003).

Large Woody Debris

TFW ambient monitoring data has not been collected for this reach; however, observations during a 1998 float trip indicate a scarcity of wood, particularly large wood and log jams (WDFW and PNPTT 2000). Wood is continually removed from the river system for private use (firewood, fence posts, etc.) and because of the illusion that the wood is contributing to flooding. It is common for small wood jams to be burned in place or for wood to be cut into short logs so they move easier down the river (Marty Ereth, personal communication, 2003).

Percent Pool

TFW ambient monitoring data has not been collected for this reach, but observations during a 1998 float trip through this reach indicate a general lack of pools with an abundance of long glides and riffles (WDFW and PNPTT 2000). There are a few good pools associated with bends in the river, lateral pools or log jams which are very limited (TAG 2003).

Pool Frequency

TFW ambient monitoring data has not been collected for this reach, but observations during a 1998 float trip through this reach indicate a lack of pool habitat (WDFW and PNPTT 2000).

Pool Quality

There are a few deep pools but cover is nonexistent (TAG 2003).

Streambank Stability

Bank failures are prevalent between the confluence with the mainstem and the confluence with Vance Creek, river mile 0.0 to 0.8. Streambank erosion can be attributed to undercutting of glacial deposits and consequent rotational and translational slope failures (USFS 1995). Additional erosion is located at approximately river mile 2.5 due to westward movement of the river through erosive soils. It can also be noted that bank armoring is often a sign of erosive soils (TAG 2003).

Sediment Input

Sediment Supply

Past timber harvest practices in the South Fork watershed have increased sediment aggradation in the deposition reaches due to mass wasting and road failures. Aggradation increases flooding, scouring/filling of redds and bed materials, streambank erosion and perpetuates the dredging/diking/aggradation cycle. In addition, there has been an 8-18% increase in peak flow duration and frequency which could imply increase sediment supply (TAG 2003).

Mass Wasting

There have been over 370 mass wasting events in the watershed involving 350,000 square meters of material. Within this segment, one mass wasting event at Red Bluff south of Boundary Lakes area contributed 209,000 square meters of material.

Road Density

There are 25.7 miles of road in the watershed between the mouth of the South Fork and river mile 12.8, yielding a road density of 2.39 miles of road per square mile of watershed, when combining this segment with the following segment. There are 31 road crossings in the two segments combined (USFS 1975). The TAG specified that the road density is poor in this segment but fair through the canyon section.

Riparian Zones

Riparian Condition

Approximately 20% of the riparian corridors in the lower South Fork is sparsely vegetated, has a buffer width of less than 66 feet, and does not provide for large woody debris recruitment that is necessary to maintain structurally diverse channels (WDFW and PNPTT 2000). Deciduous trees dominate the riparian areas that exist where historically the riparian corridor was mixed forest. Less that 50% site potential tree height exists (TAG 2003).

Water Quality

Temperature

Temperature data was collected by the Washington Department of Ecology during the mid to late 1990s but was not readily available for this report. Elevated summer temperatures have been observed in the south Fork and are partially attributable to channel widening and aggradation (TAG 2003).

Dissolved Oxygen

Dissolved oxygen is unknown.

Hydrology

It should be noted that flooding flows occur on an annual basis. It has been observed that flooding peaks have not increased but the food frequency and duration have (TAG 2003).

Flow: Hydrologic Maturity

This segment, combined with the upstream segment, is 17.6% hydrologically immature, with 26.5% in intermediate maturity and 55.9% mature (USFS 1995). The majority of this segment has been cleared for agriculture and rural development (TAG 2003).

Flow: Percent Impervious Surface
Impervious surface is a data gap.

Biological Processes

Nutrients (Carcasses)
Chinook and summer chum are federally listed as threatened and it is believed that summer chum have been extirpated from the system. Winter steelhead are listed as depressed, upper late fall chum and coho are healthy and lower fall chum and summer steelhead are unknown (SaSI 2003). Based on the number of threatened and depressed stocks, nutrients in the mainstem Skokomish are low.

Lower South Fork Action Recommendations

- Conduct river reach analysis for habitat regarding channel reconstruction, complexity restoration, floodplain acquisition, and levee removal
- Restore floodplain connectivity
  - Remove or set back all levees and dikes
  - Culvert dikes to allow flow through to overflow channels
- Restore habitat complexity and sinuosity
  - Leave existing wood in the system
  - Construct engineered logjams

South Fork Skokomish, River Mile 3.0 to River Mile 10 (Canyon)

The USFS watershed analysis combines this segment with the previous segment (river mile 0.0 to 12.8); this limiting factors analysis consequently used the combined data when reviewing their report. There are 10.76 square miles in the South Fork between river mile 0.0 and 12.8. There are 37.7 river miles yielding a drainage density of 3.5 miles of stream per square mile of watershed (USFS 1995). The canyon is 400 feet deep in some places and 60 feet wide at the narrowest (TAG 2003).

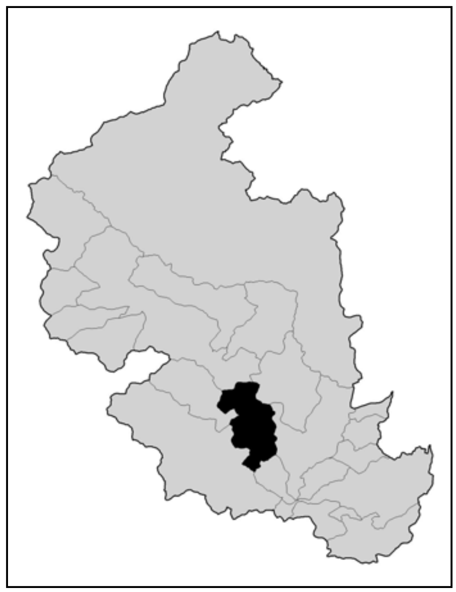

Figure 67. S.F. Skokomish Watershed, RM 3.0-10.0. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers
There are no known artificial barriers within this segment.

Floodplains
Floodplain Connectivity/Loss of Floodplain Habitat
These parameters are not applicable due to gradient.

Channel Condition

Fine Sediment

The steep gradient allows the movement of fine sediment through this segment (TAG 2003).

Large Woody Debris

There is very little wood in the canyon today. Historically, more wood was in the canyon due to larger size logs (TAG 2003).

Percent Pool

There are numerous rock walled pools throughout the canyon (TAG 2003).

Pool Frequency

Observations in the canyon estimate good pool frequency (TAG 2003).

Pool Quality

There are numerous deep clear pools within the canyon (TAG 2003).

Streambank Stability

The canyon primarily consists of stable rock walls. However, there have been some small, shallow rapid failures, but overall streambank stability is not an issue (TAG 2003).

Sediment Input

Sediment Supply

This is a sediment transport reach with deposition in the lower part that provides good spawning gravels in that area (TAG 2003).

Mass Wasting

There have been no mass wasting events in this segment with the exception of some small, shallow rapid failures (TAG 2003).

Road Density

There are 25.7 miles of road in the watershed between the mouth of the South Fork and river mile 12.8, yielding a road density of 2.39 miles of road per square mile of watershed, when combining this segment with the previous segment. In addition, there are 31 stream crossings (USFS 1975).

Riparian Zones

Riparian Condition

The valley walls have trees, mostly conifer. The existing trees, mostly conifer, on the valley walls meet natural conditions (TAG 2003).

Water Quality

Temperature
Temperature data has not been analyzed.

Dissolved Oxygen
Dissolved oxygen is unknown.

<u>Hydrology</u>

Flow: Hydrologic Maturity
This segment, combined with the downstream segment, is 17.6% hydrologically immature, with 26.5% in intermediate maturity and 55.9% mature. Approximately 69% is lowland, 26% is rain dominated and 4.5% is rain on snow (USFS 1995). Recent logging activities have clearcut the Vincent/Dalby areas (TAG 2003). The USFS is no longer clearcutting their ownership but is allowing commercial thinning to increase the momentum toward old growth development (Larry Ogg, personal communication, 2003).

Flow: Percent Impervious Surface
Percent impervious surface is unknown.

Biological Processes
Nutrients (Carcasses)
Escapement, particularly spring chinook, has been poor indicating poor nutrient conditions. However, the USFS has boosted nutrient values by implementing a nutrient enrichment program whereby carcasses from the George Adams hatchery are distributed throughout the watershed (TAG 2003).

Action Recommendations
- Remove trash from the canyon

South Fork Skokomish, River Mile 10.0 to Falls at River Mile 23.5

Throughout this segment of the South Fork Skokomish, the valley floor broadens slightly, alternately widening and narrowing (Williams et al. 1975).

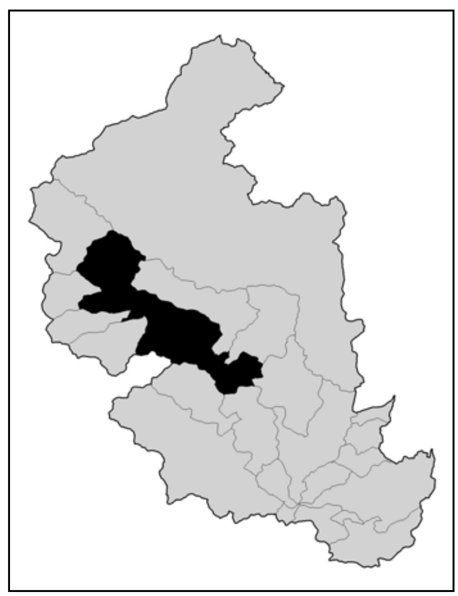

Figure 68. S.F. Skokomish Watershed, RM 10.0-23.5. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers
There are no known artificial barriers to salmon migration in this segment.

Floodplains

Floodplain Connectivity

There are no dikes or development within this segment so the river is allowed to migrate throughout the floodplain (TAG 2003).

Loss of Floodplain Habitat

There is no development in this segment and small patches old growth stands are still evident. Holman Flats is devoid of vegetation but upstream of the LeBar Creek confluence wood is present in the system (TAG 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

There is a fair to good amount of large wood, some originating within this segment and some moving down from the headwaters. Holman Flat is the only section devoid of wood (TAG 2003).

Percent Pool

There appears to be a low pool to riffle ratio in this segment (TAG 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

TAG observations indicate a general lack of quality pools.

Streambank Stability

The majority of the streambanks with the bankfull area are generally stable. There are areas of instability due to accelerated runoff from clear cutting activities. Thick regeneration is reducing sheet erosion (TAG 2003).

Sediment Input

Sediment Supply

Numerous USFS roads have been decommissioned but the sediment supply is still above the natural rate (TAG 2003).

Mass Wasting

A large mass wasting event occurred in the oxbow area but whether natural rates are exceeded within this segment is unknown. Laney Camp, in the vicinity of Church Creek, has 125-foot cut bank with cabled log jams for stability. Erosion problems are also severe in the abandoned hydropower development in the vicinity of LeBar and Brown creeks (TAG 2003).

Road Density
Road density for this segment is unknown but numerous USFS roads have been decommissioned (TAG 2003).

Riparian Zones

Riparian Condition
The lower third part of this segment is alder dominated, the middle third is dense, mature mixed forest and the upper segment is mature conifer. The USFS is actively replanting riparian corridors in the vicinity of LeBar Creek and Cedar Creek. The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature
Temperature is unknown.

Dissolved Oxygen
Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity
The forests in this segment are regenerating and are generally older than 25 years (TAG 2003).

Flow: Percent Impervious Surface
Percent impervious surface is low (TAG 2003).

Biological Processes

Nutrients (Carcasses)
Escapement is low. Bull trout are federally listed as threatened and spring chinook numbers are low. However the USFS has 32 carcass drop sites between Holman Flats and Steel Creek as part of their nutrient enrichment program (Larry Ogg, personal communication, 2003).

Figure 69. S.F. Skokomish Watershed, above RM 23.5. Map provided by Jennifer cutler, NWIFC.

Action Recommendations

- Continue riparian enhancement
- Relocate campsites away from the river
- Continue instream habitat work

South Fork Skokomish, Upstream of the Falls at River Mile 23.5

The upper 4 to 5 miles of the South Fork cut through a very narrow, steep-sloped valley, with most side hills maintaining dense conifer forest (Williams et al. 1975). Much of this segment is within natural conditions with a portion of this segment within Olympic National Park boundaries. The TAG recommends leaving this segment alone.

Vance Creek

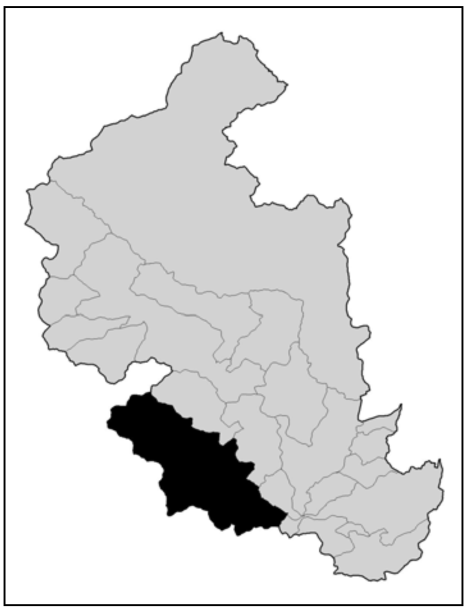

Figure 70. Vance Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Vance Creek, the largest tributary to the South fork, drains approximately 23.8 square miles (Simpson and WDNR 1997). A right bank tributary to the South fork at river mile 0.8, it contains 10.3 miles of mainstem plus 33.9 miles of tributary waters (Williams et al. 1975). Gradient is moderate through the lower 4 miles, then abruptly steepens until cascades and falls block anadromous migration at approximately river mile 7.1 (TAG 2003). The lower sections of Vance Creek contain excellent gravel although flows are intermittent in late summer and early fall downstream river mile 2.5 (Williams et al. 1975). Gravels are unstable due to lack of woody debris and high flows (Marty Ereth, personal communication, 2003). Small farms and rural housing border the lower valley reaches. The upper watershed, partly in US Forest Service ownership and partly in private timber ownership, has been extensively logged (Williams et al. 1975).

Access and Passage

Artificial Barriers

There are no known artificial barriers on Vance Creek and its tributaries. However, gravel aggradation forces flows subsurface in the low flow summer months which becomes a hydrologic barrier (TAG 200e).

Floodplains

Floodplain Connectivity

Historically, the Skokomish Valley floodplain contained numerous sloughs, side channels and forested wetlands. Today, the majority of Vance Creek has been diked and/or channelized which has eliminated access to important side channels and wetland habitats (WDFW and PNPTT 2000). The mouth of the creek has been moved to the north, which removed sinuosity in the lower channel. Baze Creek, a tributary, has also been channelized (TAG 2003).

Loss of Floodplain Habitat

The majority of the lower 3 miles of Vance Creek has been channelized, armored and/or diked, greatly reducing channel complexity, stability and sinuosity. Sparse riparian corridors remain throughout the lower reach. The streambed is aggrading partly due to the channelization and diking, and partly due to the logging activities in the upper watershed. Large gravel deposits are 300 feet wide in places. The stream is dry or subsurface during the late summer months. Diking restricts flooding flows from distributing sediments onto the floodplain, which exacerbates the aggradation and leads to further the dredging/diking/aggradation cycle. Wetlands have been converted to single channels. Two Mason County bridges further constrict channel migration (WDFW and PNPTT 2000).

Channel Condition

Fine Sediment

Personal observations indicate that the majority of fines pass through the system and in snot included into spawning gravels (Marty Ereth, personal communication, 2003).

Large Woody Debris

Habitat surveys conducted in 1994 indicate large wood counts ranging from 0.02 to 0.15 pieces per meter with much of the wood perched above the wetted perimeter, stranded on exposed gravel terraces (Skokomish DNR and PNPTC 1994, cited in WDFW and PNPTT 2000).

Percent Pool

Habitat surveys conducted in 1994 indicate 39% pool habitat. Because the surveys were conducted when the stream was dry, the data may be skewed (Kieth Dublanica, personal communication 1998, cited in WDFW and PNPTT 2000).

Pool Frequency

Pool frequency ranged between 1.5 to 2.6 channel widths between pools in 1994 but because the surveys were conducted when the stream was dry, the data may be skewed (Kieth Dublanica, personal communication 1998, cited in WDFW and PNPTT 2000).

Pool Quality

Pool quality is reduced to gravel pockets with the exception of the lower section below the confluence with Kirkland Creek where numerous deep pool with adequate cover are found (TAG 2003).

Streambank Stability

Vance Creek and its tributaries have a high number of streambank and inner gorge failures (USFS 1995).

Sediment Input

Sediment Supply

Past timber harvest practices in the Vance Creek watershed have increased sediment aggradation in the deposition reaches due to mass wasting and road failures. Sediment from the upper watershed is routed through the gorge with an estimated residence time of about 5 years and into the upper alluvial valley, where the range of sediment residence time is about 40 to 70 years. For lower Vance Creek, estimates of coarse sediment residence time range from about 10 to 20 years (Simpson and WDNR 1977). It will likely take centuries to restore (TAG 2003).

Mass Wasting

Approximately 76% of the watershed has steep erosive soils, 58% of the forest cover is less than 35 years old and approximately 50% of the watershed is subject to rain on snow events. Approximately 62% has been classified as low hazard for mass wasting, 13% medium hazard and 26% high hazard. Vance Creek and its tributaries have a high number of debris flows as well as streambank and inner gorge failures. The lower 5 miles of the watershed, particularly on the south side, are dominated by deep Vashon glacial deposits, which are particularly unstable (USFS 1995).

Road Density

Road density was 4.50 miles of road per square mile of watershed in 1992 but dropped to 4.47 miles of roads per square mile of watershed in 1995 due to road abandonment activities. In addition, there are 280 road crossings in the Vance Creek watershed (USFS 1995). The USFS has decommissioned numerous roads since 1995, including all spur roads and 2342 Road. The 2350 road (main road), 2351 road and 2352 road to Rock Creek remain open. The 2343 road is still open but is being upgraded. New logging roads on private lands are still being constructed (TAG 2003).

Riparian Zones

Riparian Condition

Approximately 32 % of the riparian corridor along Vance Creek is sparsely vegetated, is less than 66 feet in width, and does not provide for large woody debris recruitment necessary to maintain structurally diverse channels (WDFW and PNPTT 2000).

Water Quality

Temperature
Temperature is unknown.

Dissolved Oxygen
Dissolved oxygen is unknown

Hydrology

Flow: Hydrologic Maturity
Approximately 27.7% of the watershed is immature, 33% intermediate maturity and 39.3% mature. Approximately 17.7% is lowland, 32.1% rain dominated, 46.9% rain on snow and 3.2% snow dominated (USFS 1995). Recent clear cutting is occurring in the lower watershed but the forest is maturing in the upper watershed (TAG 2003).

Flow: Percent Impervious Surface
Percent impervious surface is unknown.

Biological Processes

Nutrients (Carcasses)
Chinook and summer chum are federally listed as threatened and it is believed that summer chum have been extirpated from the system. Winter steelhead are listed as depressed, upper late fall chum and coho are healthy and lower fall chum and summer steelhead are unknown (SaSI 2003). Based on the number of threatened and depressed stocks, nutrients in Vance Creek are low.

Action Recommendations

- Continue road decommissioning
- Restore channel complexity and sinuosity
- Install engineered logjams
- Restore wetland complexes
- Assess land use management, including forest management, to determine if prescriptions are adequate for fish

Rock Creek/Flat Creek

Rock Creek, 4.8 miles in length, is a left bank tributary to Flat Creek at river mile 0.55. Flat Creek, approximately 1 mile long, is a right bank tributary to the South Fork Skokomish at river mile 8.7 (Williams et al. 1975). The watershed encompasses approximately 4,145.5 acres or 6.5 square miles (USFS 1995).

Access and Passage

Artificial Barriers

An impassable falls at approximately river mile 0.1 limits anadromous access beyond this point. There are two barrier culverts on left bank tributaries to mid Rock Creek blocking movement of resident rainbow trout (Marty Ereth, personal communication, 2003).

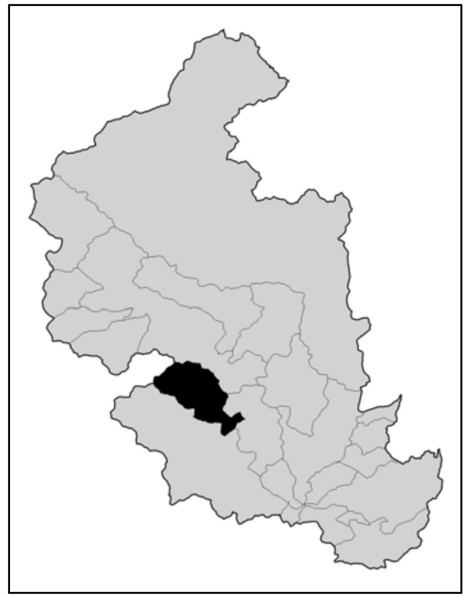

Figure 71. Rock/Flat Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity

A wetland complex is located in the lower floodplain downstream of the falls. Upstream, the floodplain flattens although it is a very small system with few fish (Larry Ogg, personal communication, 2003).

Loss of Floodplain Habitat

The floodplain reach immediately upstream of the mainline crossing has been harvested extensively. However, in the middle portions of Rock Creek, a riparian zone consisting of predominantly old growth exists. The riparian width ranges from 75 feet to over 300 feet. In this reach, side channels are evident and large wood is abundant (Marty Ereth, personal communication, 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

There is abundant wood in the system but it is primarily alder (Larry Ogg, personal communication, 2003).

Percent Pool

Rock Creek is a very slow moving system. Large wood is functioning to form pools. The percent is unknown (Larry Ogg, personal communication, 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

Pools are shallow, less than one meter deep (Larry Ogg, personal communication, 2003).

Streambank Stability

Streambanks are 80-90% stable (Larry Ogg, personal communication, 2003).

Sediment Input

Sediment Supply

Sediment moves through the system although very slowly (Larry Ogg, personal communication, 2003).

Mass Wasting

Approximately 94% of the watershed has steep slopes with erosive soils, 62% is affected by rain on snow events and 62% of the forest cover is less than 35 years old. Mass wasting potential has been evaluated at 63% low hazard, 8% medium hazard and 29% high hazard (USFS 1995).

Road Density

There are 35.94 miles of road in the Rock Creek watershed, which equated to 5.55 miles of road per square mile of watershed in 1992. Road management efforts have reduced the road density to 5.41 miles of road per square mile of watershed in 1995. In addition, there are 69 stream crossings (USFS 1995). Continued road management activities have reduced the number of roads by approximately 5 miles, or 15% of the original. This equates to a further reduced road density of 4.66 miles of road per square mile of watershed (Larry Ogg, personal communication, 2003).

Riparian Zones

Riparian Condition

The riparian zone is dominated by mature alder and big leaf maple but conifers are reestablishing due to openings in the canopy when the aging alder fall over. The riparian zone is small in the upper headwaters due to harvest (Larry Ogg, personal communication, 2003). The middle portion of Rock Creek has a good riparian zone, consisting predominantly of old growth and ranging in width between 75feet to over 300 feet (Marty Ereth, personal communication, 2003). The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature

Temperature is a data gap. The stream is shady but shallow (Larry Ogg, personal communication, 2003).

Dissolved Oxygen
Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity
Twenty two percent of the watershed is hydrologically immature, 51.7% is of intermediate maturity and 26.3% is mature. Thirty eight percent is within the rain dominated precipitation zone and 62% is within the rain on snow zone (USFS 1995).

Flow: Percent Impervious Surface
There are few, if any, impervious surfaces in the watershed.

Biological Processes

Nutrients (Carcasses)
Rainbow trout are found throughout the middle reach with a small population of non-native brook trout found upstream in a landslide created, small ponded section of the creek (Marty Ereth, personal communication, 2003).

Data Needs

- Collect temperature data

Action Recommendations

- Continue road decommissioning

Brown Creek

Brown Creek, a left bank tributary to the South Fork Skokomish at river mile 12.8, extends 7.2 miles (Williams et al. 1975). The watershed encompasses approximately 4,988 acres or 7.8 square miles. There are 37.13 miles of stream in the watershed, which yields a drainage density of 4.76 river miles per square mile of watershed (USFS 1975). It begins in gentle terrain that rapidly steepens to headwater areas that are near glacial in character (Simpson and WDNR 1997). The majority of the watershed is in USFS ownership (TAG 2003).

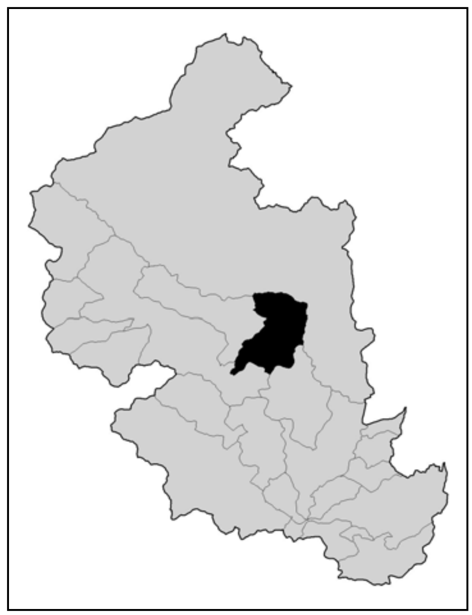

Figure 72. Brown Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

There are no known artificial barriers in this watershed. The anadromous reach extends approximately 5 miles until gradient becomes a barrier (Larry Ogg, personal communication, 2003).

Floodplains

Floodplain Connectivity

The lower 1.5 miles is floodplain with good access to side channels. The system is spring dominated and somewhat unstable (Larry Ogg, personal communication, 2003).

Loss of Floodplain Habitat

The riparian zone is healthy and is on an abandoned terrace due to downcutting (Larry Ogg, personal communication, 2003).

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Although quantitative data have not been collected, observations indicate good amounts of large wood in the system (Larry Ogg, personal communication, 2003).

Percent Pool

There is good pool formation, particularly around large wood (Larry Ogg, personal communication, 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

The majority of the pools are deeper than one meter (Larry Ogg, personal communication, 2003).

Streambank Stability

Streambank failures have been identified in Brown Creek where deep Vashon glacial deposits are particularly unstable and subject to undercutting (USFS 1995). Restoration efforts have helped to stabilize banks (Larry Ogg, personal communication, 2003).

Sediment Input

Sediment Supply

There are ample spawning gravels but they are somewhat unstable (Larry Ogg, personal communication, 2003).

Mass Wasting

Approximately 84% of the watershed has steep, erosive soils, 63% is within rain on snow elevation and 53% is less than 35 years old. Mass wasting potential in the Brown Creek watershed is 67% low hazard, 6% medium hazard and 22% high hazard. The north and east facing slopes of the upper watershed have a high number of debris flows that reach the stream (USFS 1995). The USFS has been installing log complexes to minimize the amount of sediment that reaches the system (Larry Ogg, personal communication, 2003).

Road Density

Road density in 1992 was calculated to be 4.54 miles of road per square mile of watershed. In 1995 this number was reduced to 4.19 miles of road per square mile of watershed due to road management/abandonment activities. In 1992 there were 87 stream crossings (USFS 1995). Road decommissioning has continued and all spur roads, approximately 9-10 miles of roads totally, have been decommissioned. This equates to approximately 3.27 miles of road per square mile of watershed. Only the main road, which has been upgraded and treated with bioengineering projects, remains (Larry Ogg, personal communication, 2003).

Riparian Zones

Riparian Condition

The upper headwater areas have been harvested aggressively in recent years, but patches of mature stands have been left and diverse riparian corridors are present, if vulnerable. The lower areas have been impacted by timber harvest related to an abandoned hydroelectric project, as well as by road building close to the channel (Simpson and WDNR 1997). The USFS has been girdling the alder and replanting with cedar. Under the NW Forest Plan, they are managing their riparian buffers at two site potential tree heights on fish bearing streams and one site potential tree height on non-fish bearing streams (Marc McHenry, personal communication, 2002).

Water Quality

Temperature

Brown Creek is a spring fed system and remains within a 10-14oC range in the lower four miles. Temperatures in the upper watershed are unknown but it is suspected they are good due to the old growth stands (Larry Ogg, personal communication, 2003).

Dissolved Oxygen

Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity

The upper headwater areas have been harvested aggressively in recent years, but patches of mature stands have been left and diverse riparian corridors are present but vulnerable. The lower areas have been impacted by timber harvest associated with an abandoned hydroelectric project, as well as by road building close to the channel (Simpson and WDNR 1997). Approximately 20.5% of the watershed is immature, 44.4% intermediate maturity and 35.1% mature. Approximately 35% of the watershed is less than 35 years old (USFS 1995). There are patches of old growth in the upper watershed (Larry Ogg, personal communication, 2003).

Flow: Percent Impervious Surface

Percent impervious surface is minimal (Larry Ogg, personal communication, 2003).

Biological Processes

Nutrients (Carcasses)

Escapement in the South Fork is poor. However, the USFS has been distributing carcasses in Brown Creek from the George Adams Hatchery as part of their nutrient enrichment program (Larry Ogg, personal communication, 2003).

Data Needs

- Continue collecting temperature data

Action Recommendations

- Continue road decommissioning
- Continue instream habitat and riparian restoration
- Continue slope stabilization activities

LeBar Creek

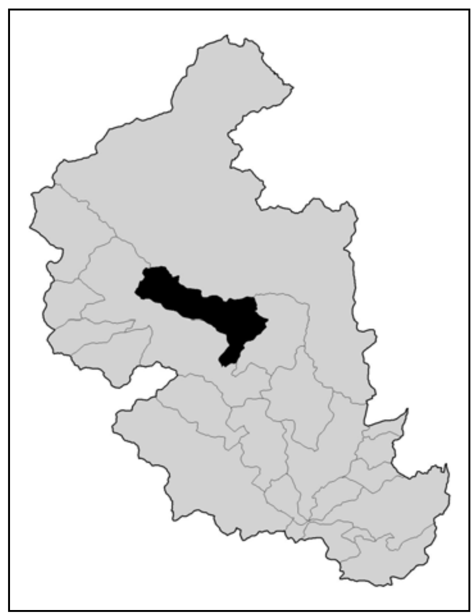

Figure 73. LeBar Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

LeBar Creek, a left bank tributary to the South Fork Skokomish at river mile 13.5, extends 7.7 miles (Williams et al. 1975). The watershed encompasses approximately 6,272.9 acres or 9.8 square miles. The total stream miles within the watershed is 40 miles with a drainage density of 4.08 river miles per square mile of watershed (USFS 1995). The majority of the watershed is in USFS ownership (TAG 2003).

Access and Passage

Artificial Barriers

Anadromous fish have access to the lower 1.1 miles of LeBar Creek. There is one culvert barrier in the upper watershed on the 2353-210 road (Larry Ogg, personal communication, 2003).

Floodplains

Floodplain Connectivity

The lower mile is floodplain habitat with no known side channels. However, the USFS has created coho overwintering ponds that are connected to the system (Larry Ogg, personal communication, 2003).

Loss of Floodplain Habitat

The floodplain is dominated by alder due to the abandoned hydroelectric project. The USFS has been replanting the area with cedar where the alder have fallen (Larry Ogg, personal communication, 2003).

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

Large wood is scarce. The only wood in the system is due to USFS restoration efforts (Larry Ogg, personal communication, 2003).

Percent Pool

Percent pool is unknown. However, large wood placement has aided in pool formation (Larry Ogg, personal communication, 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

Pool quality is unknown, although there are a few deep pools (Larry Ogg, personal communication, 2003).

Streambank Stability

Streambank failures have been identified in LeBar Creek where deep Vashon glacial deposits are particularly unstable and subject to undercutting (USFS 1995). Restoration efforts have reduced streambank failures in LeBar Creek (Larry Ogg, personal communication, 2003).

Sediment Input

Sediment Supply

Ample spawning gravels are found in LeBar Creek (Larry Ogg, personal communication, 2003).

Mass Wasting

Mass wasting potential in the LeBar Creek watershed is 50% low hazard, 14% medium hazard and 35% high hazard. Approximately 61% is within rain on snow elevation (1400 to 2900 feet), 44% of the forest is less than 35 years, and 91% is comprised of steep slopes with erosive soils (USFS 1995). The USFS has been treating mass wasting events in this watershed with revegetation and soil bioengineering projects (Larry Ogg, personal communication, 2003).

Road Density

There are 38.3 miles of road in the LeBar Creek watershed with a road density of 3.91 miles of road per square mile of watershed in 1992. Road management activities have occurred in the watershed and as a result the road density was reduced to 3.31 miles of road per square mile of watershed in 1995. In 1992 there were 81 stream crossings (USFS 1995). The USFS has decommissioned approximately 14 miles of roads in this watershed. This reduces the road density to 2.48 miles of road per square mile of watershed. All the spur roads are gone and 2-3 are scheduled to be completed during the summer, 2003. The main 2353 Road, also known as Loop Road, is still open. Road number 2353-300 will be converted to a trail in the summer of 2003 (Larry Ogg, personal communication, 2003).

Riparian Zones

Riparian Condition

The upper headwater areas have been harvest aggressively in recent years, but patches of mature stands have been left and diverse riparian corridors are present but vulnerable. The lower areas have been impacted by timber harvest related to an abandoned hydroelectric project (Simpson and WDNR 1997). The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Marc McHenry, personal communication, 2002).

Water Quality

Temperature

LeBar Creek warms up in the summer but does not exceed 15oC (Larry Ogg, personal communication, 2003).

Dissolved Oxygen
This parameter is a data gap.

Hydrology

Flow: Hydrologic Maturity
The upper headwater areas have been harvested aggressively in recent years, but patches of mature stands have been left and diverse riparian corridors are present but vulnerable. The lower areas have been impacted by timber harvest related to an abandoned hydroelectric project (Simpson and WDNR 1997). Under the NW Forest Plan, the USFS is no longer clear cutting their ownership but are only conducting pre-commercial and commercial thinning (Larry Ogg, personal communication, 2003).

Flow: Percent Impervious Surface
Impervious surface is not an issue in this watershed.

Biological Processes

Nutrients (Carcasses)
Escapement in the South Fork watershed as a whole is poor. However, the USFS has been distributing carcasses in LeBar Creek from the George Adams Hatchery as part of their nutrient enrichment program (Larry Ogg, personal communication, 2003).

Data Needs
- Continue collecting temperature data
- Monitor restoration efforts

Action Recommendations
- Continue road decommissioning
- Continue instream habitat and riparian restoration
- Continue treating unstable slopes/mass wasting

Cedar Creek

Cedar Creek, a right bank tributary to the South Fork Skokomish at river mile 17.9, extends 2.9 miles (Williams et al. 1975). The watershed encompasses approximately 3,604.4 acres or 5.6 square miles (USFS 1995).

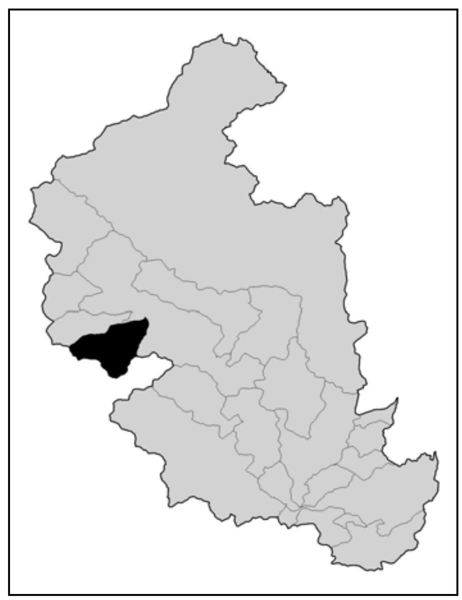

Figure 74. Cedar Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

The anadromous reach is short in Cedar Creek as a cascade/falls is at river mile 0.25. An artificial culvert barrier at approximately river mile 1.0 restricts resident fish migration (Larry Ogg, personal communication, 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable due to gradient.

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

There is ample large wood in the resident fish reaches and future wood recruitment is good. Instream restoration projects have increased the large wood and overall habitat value in the watershed (Larry Ogg, personal communication, 2003).

Percent Pool

While there is no quantitative data, professional observations indicate a good pool/riffle ratio (Larry Ogg, personal communication, 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

While there is no quantitative data, professional observations indicate a good pool quality in Cedar Creek (Larry Ogg, personal communication, 2003).

Streambank Stability

The streambanks appear stable although the creek changes course due to the wood in the system which could be considered naturally unstable (Larry Ogg, personal communication, 2003).

Sediment Input

Sediment Supply

Good spawning gravels are found in patches in this system (Larry Ogg, personal communication, 2003).

Mass Wasting

Mass wasting potential in the Cedar Creek watershed is 65% low hazard, 10% medium hazard and 25% high hazard. Approximately 68% of the watershed is within the rain on snow zone (1400 to 2900 feet elevation), 69% of the forest stand is less than 35 years old and 86% is composed of steep slopes with erosive soils (USFS 1995). The USFS has implemented slope stability projects to keep excess sediments out of the system (Larry Ogg, personal communication, 2003).

Road Density

There are 29.48 miles of roads in the Cedar Creek watershed resulting in a road density of 5.24 miles of road per square mile of watershed. There are 74 stream crossings (USFS 1995). The USFS has decommissioned approximately 6 miles of roads in this watershed, reducing the road density to 4.17 miles of road per square mile of watershed (Larry Ogg, personal communication, 2003).

Riparian Zones

Riparian Condition

The riparian zone is healthy along the steep slopes with abundant old growth throughout. To ensure future watershed health, the NW Forest Plan calls for a riparian buffer equal or greater than two site potential tree heights on fish bearing streams and one site potential tree height on non-fish bearing streams (Marc McHenry, personal communication, 2002).

Water Quality

Temperature

Cedar Creek remains cool throughout the year (Larry Ogg, personal communication, 2003).

Dissolved Oxygen

Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity

Approximately 19.1% of the watershed is immature forest, 62.6% is of intermediate maturity and 18.3% is mature. Approximately 69% of the watershed is less than 35 years old (USFS 1995). There are patches of old growth throughout (Larry Ogg, personal communication, 2003).

Flow: Percent Impervious Surface

Impervious surface is not a problem in this watershed.

Biological Processes

Nutrients (Carcasses)

Escapement is poor in this part of the watershed.

Data Needs

- Continue monitoring water temperature
- Monitor restoration activities

Action Recommendations

- Continue road decommissioning
- Continue instream and riparian habitat restoration
- Continue mass wasting/slope stability activities

Pine Creek

Pine Creek, a right bank tributary to the South Fork Skokomish at river mile 19.2, extends 4.3 miles (Williams et al. 1975). The watershed encompasses approximately 2,411.4 acres or 3.8 square miles. There are 17 miles of streams in the drainage giving it a drainage density of 4.51 river miles per square mile of watershed (USFS 1995).

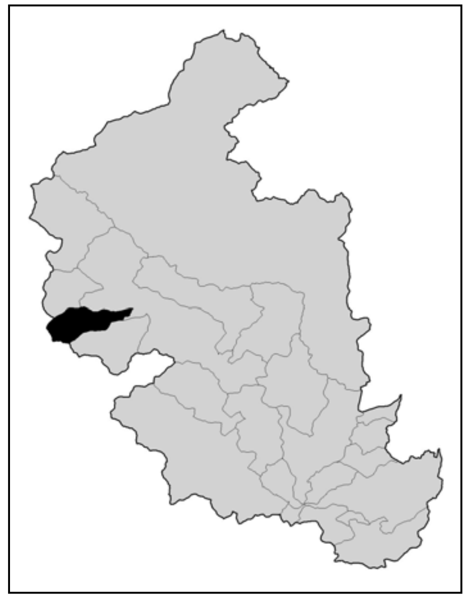

Figure 75. Pine Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Access and Passage

Artificial Barriers

Anadromous fish have access to a series of falls at approximately river mile 0.75. There are no artificial barriers within the resident fish habitat upstream (Larry Ogg, personal communication, 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

The streambanks are dominated by a rock wall canyon leaving this parameter not applicable.

Channel Condition

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

The lower, anadromous section has abundant instream wood, the middle third is the canyon and the upper watershed has a moderate amount (Larry Ogg, personal communication, 2003).

Percent Pool

While there is no quantitative pool data, personal observations indicate few pools in this system (Larry Ogg, personal communication, 2003).

Pool Frequency

Pool frequency is unknown.

Pool Quality

Personal observations indicate few deep pools in Pine Creek (Larry Ogg, personal communication, 2003).

Streambank Stability

Streambank failures in the upper watershed are due to road failures and sheet erosion (Larry Ogg, personal communication, 2003).

Sediment Input

Sediment Supply

Good spawning gravels are found in the upper watershed for resident fish but little gravel is found in the lower anadromous reach, except gravel deposits behind logs (Larry Ogg, personal communication, 2003).

Mass Wasting

Mass wasting potential in the Pine Creek watershed is 55% low hazard, 15% medium hazard and 29% high hazard. Approximately 63% of the watershed is within the rain on snow elevation, 27% of the forest stand is less than 35 years and 87% of the watershed is on steep erosive soils. The west end of the watershed has experienced a high number of debris flows due to logging and snow melt (USFS 1995).

Road Density

There are 9.33 miles of road in the Pine Creek watershed, 14 stream crossings and a road density of 2.48 miles of road per square mile of watershed (USFS 1995). Road density has not changed in this watershed but road use has. The USFS is implementing a Road to Trail project and has converted a two mile road to a trail, leaving two roads in the watershed (Larry Ogg, personal communication, 2003).

Riparian Zones

Riparian Condition

Due to the steep canyon walls through the middle section of Cedar Creek, a real riparian does not exist. Where it does exist, the NW Forest Plan guidelines apply.

Water Quality

Temperature
The water temperature remains cold throughout the year (Larry Ogg, personal communication, 2003).

Dissolved Oxygen
Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity
Approximately 8.6% of the watershed is immature forest, 35.9% is of intermediate maturity, and 55.5% is mature. Approximately 27% of the forest stand is less than 35 years (USFS 1995).

Flow: Percent Impervious Surface
Impervious surface is not a problem in this watershed.

Biological Processes

Nutrients (Carcasses)
Nutrients are unknown in this watershed.

Action Recommendations

- Continue road decommissioning

Church Creek

Church Creek, a right bank tributary to a moderately steep gradient reach of the South Fork Skokomish at river mile 21.4, extends 2.9 miles (Williams et al. 1975). There are 16.78 miles of streams within the drainage area and a drainage density of 4.29 river miles per square mile of watershed. The watershed encompasses approximately 2,500 acres or 3.9 square miles (USFS 1975).

Access and Passage

Artificial Barriers
A falls at approximately river mile 0.5 limits anadromous fish to the lower reach. There are no artificial barriers within the resident fish reaches (Larry Ogg, personal communication, 2003).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

The lower half mile is the floodplain habitat and it is intact (Larry Ogg, personal communication, 2003).

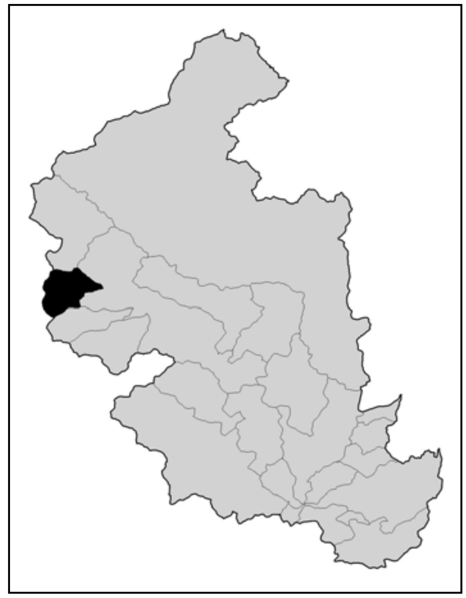

Figure 76. Church Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Channel Condition

Fine Sediment

Fine sediment is unknown.

Large Woody Debris

The only wood in the lower half mile is from USFS restoration activities. Wood in the upper watershed above the gorge is functioning well and forming pools (Larry Ogg, personal communication, 2003).

Percent Pool

Percent pool is unknown.

Pool Frequency

Pool frequency is unknown.

Pool Quality

Pool quality is unknown.

Streambank Stability

Streambanks are unstable due to cut banks. Log weirs have helped keep the gravel in the lower half mile (Larry Ogg, personal communication, 2003).

Sediment Input

Sediment Supply

Sediment supply is unknown.

Mass Wasting

Mass wasting potential has been calculated at 52% low hazard, 13% medium hazard and 24% high hazard. Approximately 67% of the watershed is within rain on snow elevation, 40% of the forest stand is less than 35 years and 88% is composed of steep, erosive soils. Approximately 12.8% is within rain dominated precipitation zone, 67.4% is within rain on snow and 19.8% is snow dominated. High densities of debris flows are found on the slopes of Mt. Church in the upper watershed (USFS 1995).

Road Density

There are 16.53 miles of road in the Church Creek watershed, 41 stream crossings and a road density of 4.23 miles of road per square mile of watershed (USFS 1995). The USFS has decommissioned 2 miles of roads to date with plans of decommissioning an additional 3 miles (Larry Ogg, personal communication, 2003). The 2 miles of decommissioned roads reduces the road density to 3.71 miles of road per square mile of watershed.

Riparian Zones

Riparian Condition

The lower half mile has a healthy riparian zone with residual old growth. The upper watershed has been harvested with only patches of old growth buffer remaining (Larry Ogg, personal communication, 2003). Riparian management in this watershed conforms with the NW Forest Plan.

Water Quality

Temperature

Water temperatures remain cool throughout the year (Larry Ogg, personal communication, 2003).

Dissolved Oxygen

Dissolved oxygen is unknown.

Hydrology

Flow: Hydrologic Maturity

Eighteen percent of the watershed is hydrologically immature, 46.7% is of intermediate maturity and 35.4% is mature (USFS 1995).

Flow: Percent Impervious Surface

Impervious surface is not a problem in this watershed.

Biological Processes

Nutrients (Carcasses)

Nutrients are unknown in this watershed.

Data Needs

- Monitor water temperatures

Action Recommendations

- Continue habitat restoration
- Continue road decommissioning

Table 16. Habitat Condition Rating Matrix

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/ NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m) / Diameter (m) / Length (m) 0-5 / 0.4 / 8 6-10 / 0.55 / 10 11-15 / 0.65 / 18 16-20 / 0.7 / 24				
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	channel widths per pool	>15 m	N/A	N/A	chann width / pools/ mile / cw/ pool 50' / 26 / 4.1 75' / 23 / 3.1 100' / 18 / 2.9	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/ WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
<u>Sediment Input</u>						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	N/A	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	N/A	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR • Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	• 75'-150' or 50-100% of site potential tree height (whichever is greater) AND • Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
<u>*Hydrology*</u>						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	N/A	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
Flow	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
<u>*Biological Processes*</u>						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC
Note: N/A = not applicable						

HABITAT CONDITION RATINGS

Table 17. WRIA 16 Habitat Condition Ratings

Stream Name/Segment	WRIA	Access	Floodplain Connect	Floodplain Habitat	Fine Sediment	LWD	% Pool	Pool Frequency	Pool Quality	Bank Stability	Sediment Supply	Mass Wasting	Road Density	Riparian Condition	Water Temperature	Dissolved Oxygen	Hydrologic Maturity	% Impervious	Nutrients
Dosewallips																			
Turner Creek	16.0559	P	P/G	F	DG	P	P	G/DG	F/P	DG	P	DG	F	DG	DG	DG	G	G	DG
Dose RM 0.0-3.6	16.0442	G	P	G	DG	P	DG	DG/G	P	P	P	G	F	P	F	DG	DG	G	P
Dose RM 3.6-12.5	16.0442	G	P	P	DG	P	DG	DG/G	P	P	G	G	G	G/P	F/G	DG	DG	G	P
Dose above RM 12.5	16.0442	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	DG
Dose - Rocky Brook	16.0449	G	NA	NA	DG	P	P	G	P	DG	DG	P	P	DG	F/G	DG	G	G	DG
Walker Creek	16.0441	G	NA	NA	DG	F	F	DG	P	DG	G	DG	P	P/F	DG	DG	P	G	DG
Duckabush																			
Duck RM 0.0-5.0	16.0351	G	F/P	P		P/F	F	DG	DG	DG	DG	P	F	P/F	F/G	DG	F	G	P
Duck RM 5.0 - 8.0	16.0351	G	NA	NA			DG	DG	DG	G	DG	P	G	G	DG	DG	G	G	P
Duck above RM 8.0	16.0351	G	NA	NA	G	G	G	G	G	G	G	G	G	G	G	G	G	G	DG
Hamma Hamma																			
McDonald Creek	16.0349	G	G	F	G	F	F	F	DG	F	P	G	P	P	F/P	DG	P	G	DG
Fulton Creek	16.0332	G	F	G	DG	P	P	DG	DG	DG	G	DG	G	G	P	DG	G	G	DG
Schaerer Creek	16.0326	G	G	G	DG	DG	DG	DG	DG	DG	DG	P	P/G	DG	DG	DG	G	G	DG
Unnamed Trib (Mikes Bch)	16.0325	P	P	P	DG	DG	DG	DG	DG	DG	P	DG	P	DG	DG	DG	G/P	DG	DG
Waketickeh Creek	16.0318	G	P	P	DG	DG	DG	DG	DG	DG	DG	DG	P	F	DG	DG	G	G	DG
Hamma RM 0.0-1.5	16.0251	G	P	F	DG	P	F	DG	DG	G	G	DG	P	P	G	DG	DG	G	F/P
Hamma RM 1.5-2.3	16.0251	G	NA	NA	DG	P	F	DG	DG	G	DG	DG	P	G	DG	DG	DG	G	F/P
Hamma above RM 2.3	16.0251	DG	G	G	DG	G/DG	P	DG	DG	DG	DG	DG	G	G	DG	DG	F	G	DG
Johns Creek	16.0253	G	F	F	F	P/G	F	DG	P	DG	P	P	F	P/F	F	DG	G	G	F/P

Stream Name/Segment	WRIA	Access	Floodplain Connect	Floodplain Habitat	Fine Sediment	LWD	% Pool	Pool Frequency	Pool Quality	Bank Stability	Sediment Supply	Mass Wasting	Road Density	Riparian Condition	Water Temperature	Dissolved Oxygen	Hydrologic Maturity	% Impervious	Nutrients
Lilliwaup																			
Jorsted Creek	16.0248	G	P	P	DG	P	DG	DG	DG	F	DG	F	P	DG	DG	DG	G	G/P	DG
Eagle Creek	16.0243	G	F	G	DG	F	DG	DG	DG	G	DG	DG	P	DG	DG	DG	G	G	
Lilliwaup RM 0.0-0.7	16.0230	G	P	P	DG	P	DG	DG	DG	F	G	G	P	P	DG	DG	G	G	G
Lilliwaup above RM 0.7	16.0230	G	G	G	DG	DG	DG	DG	DG	G	DG	G	P	G	DG	DG	G	G	DG
Little Lilliwaup	16.0228	G	F	F	DG	DG	DG	DG	DG	G	G	G	DG	G	DG	DG	DG	DG	DG
Sund Creek	16.0226	G	P	P	DG	P	DG	DG	DG	DG	P	G	F	P	DG	DG	G	DG	DG
Miller Creek	16.0225	G	P	P	DG	P	DG	DG	DG	P	P	G	P	P	DG	DG	G	DG	DG
Clark Creek	16.0224	G	P	P	DG	P	DG	DG	DG	G	DG	DG	DG	F	DG	DG	DG	DG	DG
Finch Creek	16.0222	P	P	P	DG	P	DG	DG	DG	P	G	G	P	P/G	DG	DG	G	G	P
Hill Creek	16.0221	G	NA	NA	DG	P	DG	DG	DG	G	DG	DG	P	G	DG	DG	DG	DG	P
Skokomish																			
Unnamed Creek (Canal Side)	16.0220	P	P	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Minerva Creek	16.0218	P	P	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Potlatch Creek	16.0217	P	P	P	DG	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Enetai Creek	16.0216	P	P	P	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Skokomish, RM 0.0-9.0	16.0001	G	P	P	DG	P	DG	DG	DG	G	P	NA	P	P	DG	DG	P	DG	P
Purdy Creek	16.0005	G	G	G	DG	G	DG	DG	DG	DG	G	DG	P	P/G	G	DG	P	G	DG
Weaver Creek	16.0006	G	P	P	DG	P	P	P	P	DG	DG	NA	P	P	G	DG	P	G	DG
Hunter Creek	16.0007	G	P	P/F	DG	P	P	P	P	DG	DG	G	P	P	G	DG	P	G	DG
Richert Springs	16.0009	G	G	G	DG	G	G	G	G	G	DG	NA	DG	F/G	DG	DG	F	G	DG
NF Skok, mouth to RM	16.0001																		

Stream Name/Segment	WRIA	Access	Floodplain Connect	Floodplain Habitat	Fine Sediment	LWD	% Pool	Pool Frequency	Pool Quality	Bank Stability	Sediment Supply	Mass Wasting	Road Density	Riparian Condition	Water Temperature	Dissolved Oxygen	Hydrologic Maturity	% Impervious	Nutrients
17.3																			
NF Skok, above RM 17.3	16.0001																		
McTaggert Creek	16.0105																		
SF Skok, mouth to RM 3.0	16.0011	G	P	F	F	P	P	P	P	P	P	P	P	P		DG	P	DG	P
SF Skok, RM 3.0-10.0	16.0011	G	NA	NA	G	P	G	G	G	G	P	G	F	G	DG	DG	F	DG	G
SF Skok, RM 10.0-23.5	16.0011	G	G	G	G	F/G	P	P	G	G/F	P	P	DG	F	DG	DG	G	G	G
SF Skok, above RM 23.5	16.0011	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	DG
Vance Creek	16.0013	G	P	P	F	P	P	P	P	P	P	P	DG	DG	DG	DG	P	DG	P
Rock Creek	16.0038	G	DG	F	DG	G	DG	DG	P	F	G	DG	P	G	DG	DG	F/P	G	P
Brown Creek	16.0047	G	G	F	DG	G	GG	DG	G	P	G/P	P	P	G	G	DG	P	G	G
LeBar Creek	16.0053	G	G	F	DG	P	P	DG	DG	P	G	P	F	G	F	DG	P	G	G
Cedar Creek	16.0066	P	NA	NA	DG	G	G	DG	G	FF	G	F	P	G	G	DG	P	G	P
Pine Creek	16.0071	G	NA	NA	DG	P	P	DG	P	P	P/G	P	F	G	G	DG	F/P	G	DG
Church Creek	16.0077	G	G	G	DG	F	DG	DG	DG	P	DG	P	P	F	G	DG	P	G	DG
G = good																			
F = fair																			
P = poor																			
DG = data gap																			

NEARSHORE INTRODUCTION

The nearshore environment consists of salt marshes, tidal flats, tidal channels, eelgrass and kelp beds, bluffs, riparian vegetation, forage fish spawning grounds and shallow water migration corridors along the shorelines. Salmonid use of the nearshore environment is well documented. Chinook, coho, steelhead and chum spawn in streams that empty into estuaries along the shorelines of WRIA 16. They are known to use the nearshore for protection from predators, feeding and migration. Chinook are particularly fond of tidal channels and sloughs while chum feed on copepods found on eelgrass. Chinook and coho eventually feed on smaller fish, such as sand lance, herring and surf smelt. The protection of these habitats depends on the protection of the shoreline processes that create and maintain the habitats.

The Nearshore Technical Advisory Group (TAG) developed a Stressor-Effects Table on which to base their discussions and analysis. The table can be found following the nearshore segment discussions. The Stressor-Effects Table identifies five stressors that impact nearshore environments: shoreline armoring, over-water structures, ramps/rail launches, stormwater/wastewater, landfill and riparian loss. The Table then points to the physical/chemical effects, habitat effects and juvenile salmon effects of each stressor. Each section also describes physical attributes of each drift cell (location, drift direction, and sediment abundance) as well as biotic background to present a picture of the landscape. Following the nearshore discussion is a prioritized list of nearshore action recommendations for use in prioritizing projects in the nearshore.

For their analysis, the TAG used geo-referenced mid-late 1800s United States Coast and Geodetic Survey (USC&GS) topographic charts to provide a picture of historic conditions. The TAG compared these historic maps with current 2000 aerial orthophotos from Washington Department of Natural Resources (WDNR) and current oblique shoreline photos from Washington Department of Ecology (Ecology) to determine habitat change over time. WDNR's Shorezone Inventory and Ecology's net shore drift maps provided additional information as did the WDFW's forage fish habitat surveys. The TAG decided not to rate the elements of the Stressor-Effects Table but to identify and describe their impacts where possible.

The shoreline/nearshore has been divided into geographic units for ease of discussion. They include all estuaries within their boundaries. Estuary discussions are also associated with their corresponding watershed. The nearshore units are:

Right Smart Cove to Quatsap Point
Quatsap Point to Triton Head
Triton Head through Hamma Hamma
Hamma Hamma through Lilliwaup
Lilliwaup through Skokomish

The resulting action recommendations focus on restoring natural nearshore and estuarine processes and functions as well as connecting juvenile migration corridors. Following is the report:

RIGHT SMART COVE TO QUATSAP POINT

Right Smart Cove to Quatsap Point begins at the northern most shoreline in WRIA 16 and extends southward to include the Dosewallips River Delta, Pleasant Harbor and part of Black Point. Four drift cells are found within this segment.

Drift Cell and Biota Background

The northernmost drift cell in WRIA 16, Ecology designation JE-24, originates near the southernmost portion of the Dosewallips River Delta and has generally northward net shore-drift for 5.2 km to Right Smart Cove, a small bay located 2 km north of Seal Rock in western Dabob Bay. A substantial portion of sediment from the Dosewallips River that is deposited in the nearshore appears to be transported northward by net shore-drift from the currently active southeastern portion of the delta. This is due to the 6 km of southerly fetch that this portion of the fan-shaped delta is exposed to, while it is mostly sheltered from north and northeast waves. The northern portion of the delta is currently inactive, but is broader and has a more gradual delta front depth gradient than that on the southeast portion of the delta. Thus, generally northward net shore-drift across the Dosewallips River Delta is indicated by northward beach width increase (Johannessen 1992).

North of the Dosewallips River Delta, northward net shore-drift is indicated by sediment accumulation on the southern side of a rip-rap seawall and boat ramp at the community of Seal Rock, northward directed creek mouth and delta at Turner Creek, and overall increase in beach width and decrease in sediment size moving northward (Johannessen 1992). The majority of the drift is alongshore with fluvial deposits at the mouth of Turner Creek and the Dosewallips River (WDNR 2001). There is only a small alluvial fan at this estuary (TAG 2003). Beach width is narrowest immediately north of the Dosewallips River, measured at 17 feet and increasing to 30 feet at the cell terminus (WDNR 2001). The drift cell terminus is located in the northernmost portion of the bay that is northwest of Wawa Point, at a zone of a drift convergence in common with net shore-drift moving northwestward from Wawa Point (Johannessen 1992).

A high salt marsh is located in the northernmost part of the segment and another in the southernmost part of the segment at Sylopash Point. The intertidal zone is a 360-foot wide sand flat at this point. Patches of barnacles and oysters are found along the entire shoreline (WDNR 2000). Juvenile chum and pink salmon have been observed in Wolcott Slough (Hirschi et al. 2003b). Herring spawn in the eelgrass along the shoreline of Right Smart Cove, extending south to the mouth of Turner Creek (Penttila et al. 2000).

The next drift cell to the south, Ecology designation JE-25, originates at a point of divergence with the drift cell to the north at the southern extent of the Dosewallips River delta. This drift cell extends southeastward for 2.1 km to Pleasant Harbor. South of the delta, northeasterly fetch becomes the factor controlling net shore-drift since the shore here is sheltered from southerly waves by Black Point. Southwestward net shore-drift is indicated by minor southwestward beach width increase and sediment size decrease, and southwestward spit progradation (for 150 m) at a location just inside of the narrowest portion of the mouth of Pleasant Harbor. The end of this spit is the cell terminus (Johannessen 1992). Beach width at the divergent zone ranges between 360 feet and 455 feet due to the Dosewallips River delta but decreases immediately to the south of fluvial influence. Sediment is abundant at the delta but becomes moderate in abundance moving alongshore toward the south (WDNR 2001). Many good side channel habitat and distributary channels are still intact, while others have been severely impacted (TAG 2003). Barnacles and oysters are continuous along the shoreline and aquaculture activity is present at Sylopash Point (WDNR 2001). Sand lance have been observed spawning along the north shore of the mouth of Pleasant Harbor (Penttila et al. 2000). Pleasant Harbor is a naturally deep marina with patches of salt marsh, fucus and barnacles (WDNR 2001). A thin band/fringe of eelgrass lines portions of the north shore (TAG 2003).

Figure 77. Basalt outcroppings, Black Point, 2000. Ecology oblique photo #103310.

The third drift cell along this segment, Ecology designation JE-26, is a 0.5-km-long cell that has westward then southwestward net shore-drift across the northern portion of Black Point and into Pleasant Harbor. The cell originates immediately west of a basalt point located on northeast Black Point (Johannessen 1992). The area was historically noted as Indian Camp (TAG 2003). Drift sediment is derived from glacial drift that overlays the basalt. Indicators of westward net shore-drift are westward and southwestward bluff vegetation increase, sediment size decrease, and progradation of a wide beach to a location inside of the narrowest portion of the mouth of Pleasant Harbor, directly across from the Pleasant Harbor Marine State Park. Net shore-drift in this cell matches that of the cell on the opposite side of Pleasant Harbor (Johannessen 1992). An inclined cliff dominates the background of this drift cell with backshore and alongshore sediment sources of scarce to moderate abundance. Fucus and barnacles are found along the shoreline (WDNR 2001).

The final drift cell in this segment, Ecology designation JE-27, originates at the east-northeast portion of Black Point and has a generally southward net shore-drift for 2.0 km along a sinuous shore to Quatsap Point. This area is exposed to northerly and northeasterly fetch, which controls net shore-drift. Evidence of generally southward net shore-drift is provided by an overall southward sediment size decrease, southeastward steam mouth offset near the center of the cell, and southeastward progradation of Quatsap

Point, a cuspate spit with a very distinct triangular plan shape. The cell terminus is located at Quatsap Point (Johannessen 1992). Quatsap Point is an undisturbed salt marsh with a wide beach and should be protected. Feeder bluffs adjacent to Quatsap Point should also be protected (TAG 2003).

Figure 78. Quatsap Point, 2000. Ecology oblique photo #103156.

This drift cell begins with a steep cliff as a backdrop and ends with a low inclined cliff. The moderately abundant sediment source is alongshore, with the exception of fluvial influence of a small stream. The intertidal zone varies between 20 to 25 feet in width. Dune grasses are found at the cell origin and again at the cell terminus. Patches of barnacles and fucus are found along the shore (WDNR 2001). Herring spawn along the entire shoreline (Penttila et al. 2000).

Shoreline Armoring

Approximately 2,149 meters of the shoreline within this segment, or 14% of the shoreline, are bulkheaded (Hirschi et al. 2003). These numbers are considered conservative. Combined armoring from transportation and residential development effectively disrupts most backshore sediment recruitment (TAG 2003). A long bulkhead encroaches partially onto the ordinary high water line north of the Turner Creek estuary (TAG 2003). An undersized culvert at Highway 101 restricts sediment recruitment from Turner Creek and is a total barrier to fish migration (Johnson et al. 2001). Seal Rock Campground sits on bedrock supplemented with riprap at the toe of a slope. The necessity of this riprap should be investigated. In addition, there is a discontinuous but significant length of riprap armor protecting the base of SR101 north of Wolcott Sough and extending to Right Smart Cove (TAG 2003).

The southern bank of the tidally influenced portion of the Dosewallips River has been armored with riprap for several hundred feet. This structure may have contributed to the simplification of the mainstem of the Dosewallips River and disconnection to its distributary sloughs.

Overwater Structures

Twelve docks, some more elaborate than others, some with extensive stairways, some with platform rafts and some associated with bulkheads are found to the south of Walker

Creek. Boathouses with rail tracks and pilings are also in this vicinity. A long pier with a float is to the north of Quatsap Point (TAG 2003). A large marina within Pleasant Harbor has approximately 350 slips (WDNR 2001). A dock on WDFW property at the end of the harbor is scheduled for removal (Bob Burkle, personal communication, 2003).

Ramps

Nine boat ramps are in the vicinity of a housing development to the north of Seal Rock but do not appear to impede sediment drift (TAG 2003). The WDFW boat launch in Pleasant Harbor is scheduled for replacement with a concrete ramp (Bob Burkle, personal communication, 2003).

Stormwater/Wastewater

Drainage from the parking lot at Seal Rock Campground should be investigated (TAG 2003). Multiple creosoted pilings from abandoned piers in Wolcott Slough not only threaten water quality but also limit available juvenile salmon habitat directly (displacement) and indirectly (decreased tidal prism and increased sedimentation) and should be removed (TAG 2003).

Landfill

Roadway fill associated with a shellfish facility imposes into the intertidal area, thereby impairing juvenile salmon migration and nearshore food webs. A derelict structure, also associated with the aquaculture activities, should be removed (TAG 2003). An undersized culvert at the mouth of Turner Creek restricts fluvial deposits into the marine environment and is a complete barrier to fish migration (Johnson et al. 2001). South of the same estuary is a 130-foot (42m) bulkhead that encroaches onto the intertidal zone while long bulkhead encroaches partially onto the ordinary high water line north of the Turner Creek estuary. Within this segment is a paved area extending onto the intertidal zone with associated pilings and adjacent ramps (a minimum of nine). An adjacent boathouse also extends over the ordinary high water line. Both the paved area and the boathouse interrupt sediment drift and impact migrating juvenile salmonids by eliminating shallow water habitat for escape from predators (TAG 2003).

Within the Dosewallips estuary/delta, Wolcott Slough has been impacted by fill. At least two culverts and their associated fill at SR101 restrict tidal flows within Wolcott Slough and at least partially restricts adult and juvenile fish migration upstream of the highway. Historically a long tidal channel, which is considered the main channel of Wolcott Slough, extended upland beyond the rhododendron gardens to the west of SR101. To the east of SR101, an access road through the salt marsh is built on fill that disconnects and restricts tidal channels. The placement of bridges on this access road would restore partial tidal function, but removal of the entire road would increase salt marsh habitat. Further to the south, remnant dikes should be removed (TAG 2003).

To the south, Sylopash Slough, is restricted by a culvert under an access road and should be replaced with a bridge. An upper road/driveway seaward of SR101 on Sylopash

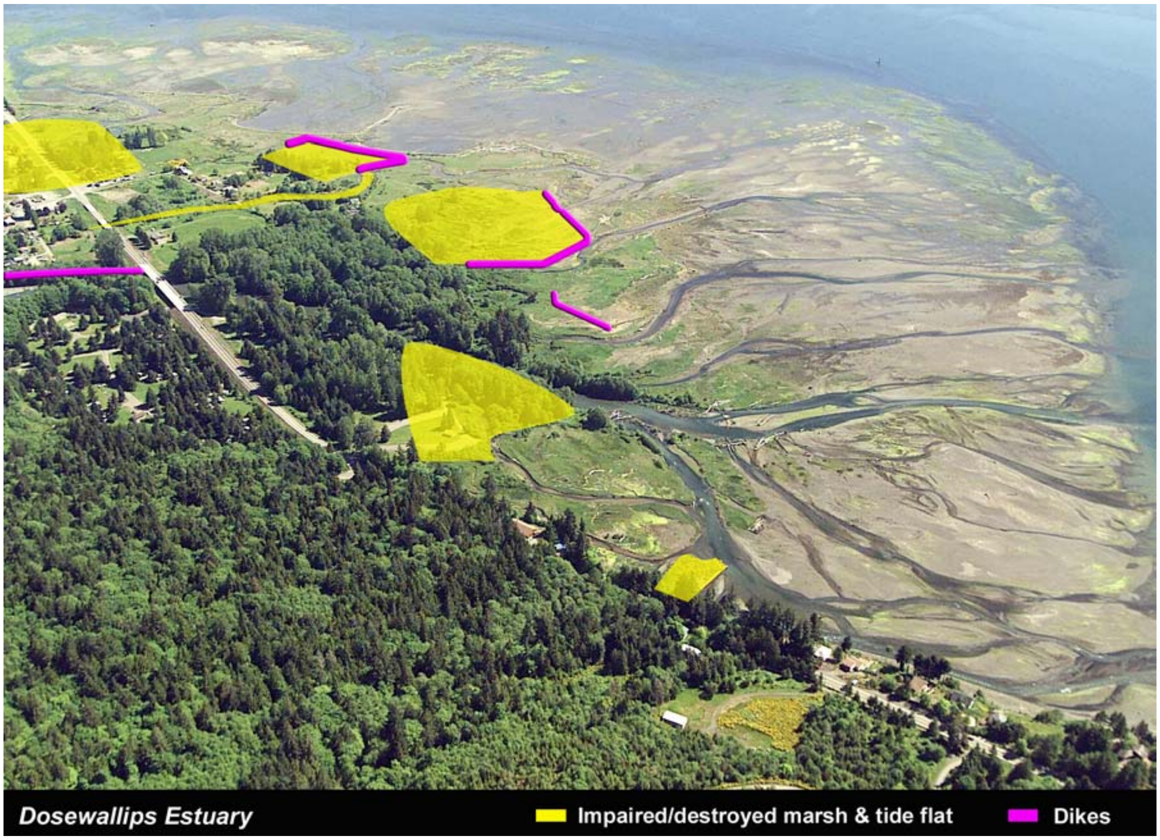

Figure 79. Dosewallips Estuary, 2003. Graphic provided by Randy Johnson, WDFW.

Slough should also be bridged and dikes to the south should be removed. An old derelict barge at the mouth of Walkers Creek, also known as James Creek, should be removed (TAG 2003).

A concrete bulkhead with fill is between Walker Creek and Pleasant Harbor. Upon entering Pleasant Harbor, structures inside of an accretion spit should be removed to restore salt marsh habitat. Within Pleasant Harbor itself, fill for the parking lot for the northern marina encroaches onto the intertidal zone. Fill in front of the swimming pool also impacts the nearshore. WDFW property at the end of the harbor is filled for a parking lot (TAG 2003). Site restoration planning is in the final stages and will include removal of the majority of the fill, removal of the creosote pilings and pier, reinstallation of a concrete boat launch with boarding float, site revegetation and replacement of an undersized culvert (Bob Burkle, personal communication, 2003). An undersized culvert associated with a tidal lagoon along the northern side of Black Point should be replaced with a bridge. The channel cuts through bedrock and the mouth has been filled. Other open water areas with associated salt marsh habitats along the shoreline of Black Point have been filled. Historic grasslands to the north of Quatsap Point have been filled to accommodate housing.

Riparian Loss

The riparian zone has been systematically removed or degraded throughout this area. Riprap protecting SR 101, access roads, a shellfish facility and residential development have taken the place of the natural vegetation zone, an impact to chinook and other juvenile salmonids that rely on terrestrial insects for forage and an impact to the nearshore environment in general (TAG 2003).

Data Needs

- Investigate drainage at Seal Rock
- Investigate the impacts from long-term alterations to intertidal substrate composition resulting from shellfish culture activities on the natural physical and biological processes and functions supporting salmon and the nearshore community
- Investigate the degradation/impacts from the switch from nearshore to riverine-derived sediments as a result of the increased sediment in rivers from land use practices and decreased sediments in nearshore from bank armoring, residential development and road construction.

Action Recommendations

- Remove paved area and adjacent boathouse associated with a housing development to the north of Seal Rock campground to reestablish sediment drift and contiguous shallow water habitat for fish migration
- Investigate necessity of riprap at Seal Rock Campground parking lot
- Investigate drainage at Seal Rock Campground parking lot and ameliorate if necessary
- Remove derelict structure associated with the aquaculture activities between Seal Rock and the Dosewallips estuary
- Replace the SR101 culvert at the northern part of Wolcott Slough with a bridge; provide tidal channel connection with bridge on access road to east of SR101; replace undersized culvert with bridge over slough to the south; remove dikes; connect upper tidal channel west of SR101 with larger lagoon with a bridge on access road
- Restore Sylopash Slough tidal prism and riparian condition
- Examine the seal exclusion fence and/or look at alternatives
- Remove dike between Wolcott Slough and the Dose mainstem on Washington State Parks property
- Remove the dikes in the vicinity of the mainstem Dosewallips River
- Remove the barge at the mouth of Walker Creek
- Remove pilings to the south of Walker Creek
- Remove structures inside of accretion spit and restore salt marsh and riparian vegetation at the mouth of Pleasant Harbor
- Remove fill associated with a parking lot on WDFW property at the end of Pleasant Harbor

QUATSAP POINT TO TRITON HEAD

Five drift cell units, with two areas of no appreciable net shore-drift included as well, are discussed in this segment between Quatsap Point and Triton Head along the western shore of Hood Canal.

Drift Cell and Biota Background

The first drift cell, Ecology designation JE-28, originates at the central portion of the Duckabush River Delta and has northeastward and eastward net shore-drift for approximately 2.2 km to Quatsap Point as indicated by nearshore bars oriented east-west moving to the northeast across the delta, northeastward offset of the main distributary channel of the Duckabush River, eastward beach width increase along Black Point, and southeastward progradation of Quatsap Point, a cuspate spit that is the location of the drift cell terminus (Johannessen 1992). The sediment source is mainly alongshore in moderate abundance with an intertidal zone extending 515 feet in width (WDNR 2002). An active feeder bluff along the south shore of Quatsap Point extends 1,556 meters (Hirschi et al. 2003) and provides backshore sediment for the wide beach (TAG 2003). Patches of ulva and barnacles are found along the open sandy beach and delta fan. The sediment source becomes fluvial with moderate abundance at the mouth of the Duckabush River and the intertidal zone extends to 750 feet in width (WDNR 2000). Herring spawn around Black Point (Penttila et al. 2000). Existing salt marsh habitat has been truncated by SR101 along the Duckabush Delta. Progradation of the delta has resulted in a gain of salt marsh habitat seaward of the historic delta boundaries. A salt marsh at the cell terminus at Quatsap Point is undisturbed and should be protected (TAG 2003).

No appreciable net shore-drift occurs along the rocky shore southwest of the Duckabush River Delta to McDaniel Cove. The shore here consists of basalt outcroppings with isolated beaches in between (Johannessen 1992). Sediment source is predominantly alongshore in moderate abundance with occasional backshore contribution in scarce abundance. A small unnamed drainage contributes fluvial sediments in moderate abundance. The intertidal zone varies between 2 and 30 feet al.ong this narrow shoreline. Patches of fucus, barnacles and oysters are found in this segment. Riparian varies between 0 and 40% (WDNR 2000). A salt marsh is still intact to the south of the Duckabush (TAG 2003).

The next drift cell, Ecology designation JE-29, originates at the location 1.2 km northeast of the Fulton Creek outlet. Net shore-drift is to the northeast around an unnamed point, then to the northwest to a riprap jetty in McDaniel Cove, for a total distance of 0.7 km (Johannessen 1992). The majority of sediment source is along shore in moderate abundance with moderate fluvial amounts from an unnamed tributary. An exposed segment toward the southern end of the drift cell contributes a moderate amount from backshore source (WDNR 2000). Indicators of northeastward then northwestward net shore-drift are accumulations of sediment on the southwest side of rock outcrops partially interrupting drift and sediment size decrease over the length of the cell. The point is composed of basalt and is not depositional. Net shore-drift continues around the point and terminates at the riprap jetty in McDaniel Cove (Johannessen 1992). The intertidal zone varies between 10 and 35 feet in width. Patches of oysters and barnacles are found along the shoreline with additional patches of lichen and fucus to the south. Riparian varies between 100% at the beginning of the drift cell but has been eliminated northward until the end of the drift cell where it approaches 50% (WDNR 2000).

The third drift cell, Ecology designation JE-30, within this segment is located in the small embayment immediately north of Triton Cove. The cell originates 100 m north of the largest rocky prominence that defines the north end of Triton Cove, located north-northwest of Triton Head. Net shore-drift is northeastward for 1.7 km (Johannessen 1992). Sediment source is fluvial with a delta fan from a small watershed draining into Hood Canal near the terminus of this drift cell and is of moderate abundance. Sediment source is alongshore of moderate abundance along a sand beach and is fluvial of moderate abundance at the delta fan of Fulton Creek at the origin of the drift cell (WDNR 2000). Northeastward net shore-drift is determined by northeastward stream mouth and delta offset near the beginning of the cell, northeastward beach width increase up to the Fulton Creek delta, northeastward sediment size decrease, and the accumulation of sediment on the southwest side of several rock outcrops near the cell terminus. The cell terminus is located 0.5 km northeast of where Fulton Creek passes beneath highway 101 (Johannessen 1992). The intertidal zone ranges from 17 feet to 135 feet in width. Patches of barnacles, oysters and fucus are found along the shoreline. Riparian cover varies between 20% along the north near the terminus and 60% to the southern end, or origin, of the drift cell (WDNR 2000). Juvenile chum, coho and chinook have been observed in the tidally influenced reaches of Fulton Creek (Hirschi et al. 2003b).

No appreciable net shore-drift occurs along the rocky northwest shore of Triton Cove. The shore is composed of basalt with little beach sediment present. The head of Triton Cove receives sediment from a small creek, but the wave energy present within Triton Cove is directed into the cove, not out of it, resulting in no net shore-drift (Johannessen 1992). The sediment source is alongshore of moderate abundance. The intertidal zone is approximately 25 feet wide. Continuous oysters and patches of barnacles are found along the sandy beach. The riparian zone is 20% cover along the shoreline (WDNR 2000). The Jefferson/Mason County boundary is located in southern Triton Cove.

The fourth drift cell, Ecology designation MA-1-1, is within Triton Cove originating to the northeast of Triton Cove with southwest transport indicated by sediment accumulation on the northeast and erosion on the southwest of several groins. In addition, the beach becomes wider to the southwest (Schwartz 1992). Sediment source is alongshore of moderate abundance (WDNR 2000). Triton Cove is protected from prevailing southwest winds by a basalt headland and is open to the northeast such that northeast winds with a fetch of up to 20 km become the predominant drift influence (Schwartz 1992). The intertidal zone is approximately 20 feet wide. Continuous barnacles and fucus are found along the sandy shoreline. Riparian habitat is non-existent along this segment (WDNR 2000).

The fifth drift cell, Ecology designation MA-1-2, originates near the northern tip of Triton Head and terminates to the west in Triton Cove. Although there is not a large supply of sediment for transport, there are slight accumulations east of boat launch rails which extend across the shore (Schwartz 1992). Sediment source is alongshore and of moderate abundance (WDNR 2000). Triton Head is formed of more resistant basaltic rocks of the Crescent Formation and extends into deep water resulting in no appreciable net shore-drift, although in extreme storm conditions there may be some sediment bypass (Schwartz 1992). The intertidal zone is approximately 17 feet wide. Continuous barnacles and patches of focus are found along the sand and gravel beach. The riparian zone is 40% cover along this southern shore of Triton Cove (WDNR 2000).

Shoreline Armoring

Concrete bulkheads and riprap to the north and to the south of the Duckabush appear to be landward of the intertidal zone. Riprap has been placed along the north side of the Fulton Creek estuary with fill for a front yard. Toward the south end of Fulton Creek delta riprap extends into the intertidal area to protect a home and a road. Moving south, riprap and fill for a WDFW parking area extends into the intertidal zone to the south of an independent tributary and should be relocated (Ecology 2001; TAG 2003). Approximately 1,255 meters of the shoreline in this segment, or 9% of the shoreline, has been bulkheaded (Hirschi et al. 2003). These numbers are considered conservative. Combined armoring from transportation and residential development effectively disrupts most backshore sediment recruitment (TAG 2003).

Overwater Structures

A long dock with float is north of the Duckabush River mouth and is associated with a small settlement of four or five houses. All have bulkheads but they are at the ordinary high water line. Historically the area was a spit that has been filled in. Between the Duckabush River and McDaniel Cove are two docks, two boathouses that are built over the water and three marine railways. Multiple docks at Triton Cove State Park should be combined into one dock. Within Triton Cove is a long dock and numerous marine buoys (Ecology 2001; TAG 2003).

Figure 80. Black Point Lagoon, 2000. Ecology oblique photo #103242.

Ramps/Rail Launches

Three rail launches are between the

Duckabush River and McDaniel Cove. Several rail launches are between McDaniel Cove and the Fulton Creek delta. There are boat ramps to the north of Triton Cove, but due to the steepness of the beaches, sediment transport is not interrupted. A very large public boat ramp at Triton Cove is on a steep beach and does not appear to be interrupting sediment transport. There are marine rail launches near and within Triton Cove (Ecology 2001; TAG 2003).

Stormwater/Wastewater

Stormwater and bilge water remediation and education are needed at Triton Cove State Park (TAG 2003).

Landfill

Tidal connection between salt water and Black Point Lagoon has been degraded due to road fill and a tide gate. The water in the lagoon is controlled for swimming is emptied into the bay on a weekly basis, creating warmer water temperatures in the marine environment. The tide gate and fill should be removed to allow the swimming pond to return to salt marsh and a tidally influenced lagoon (TAG 2003).

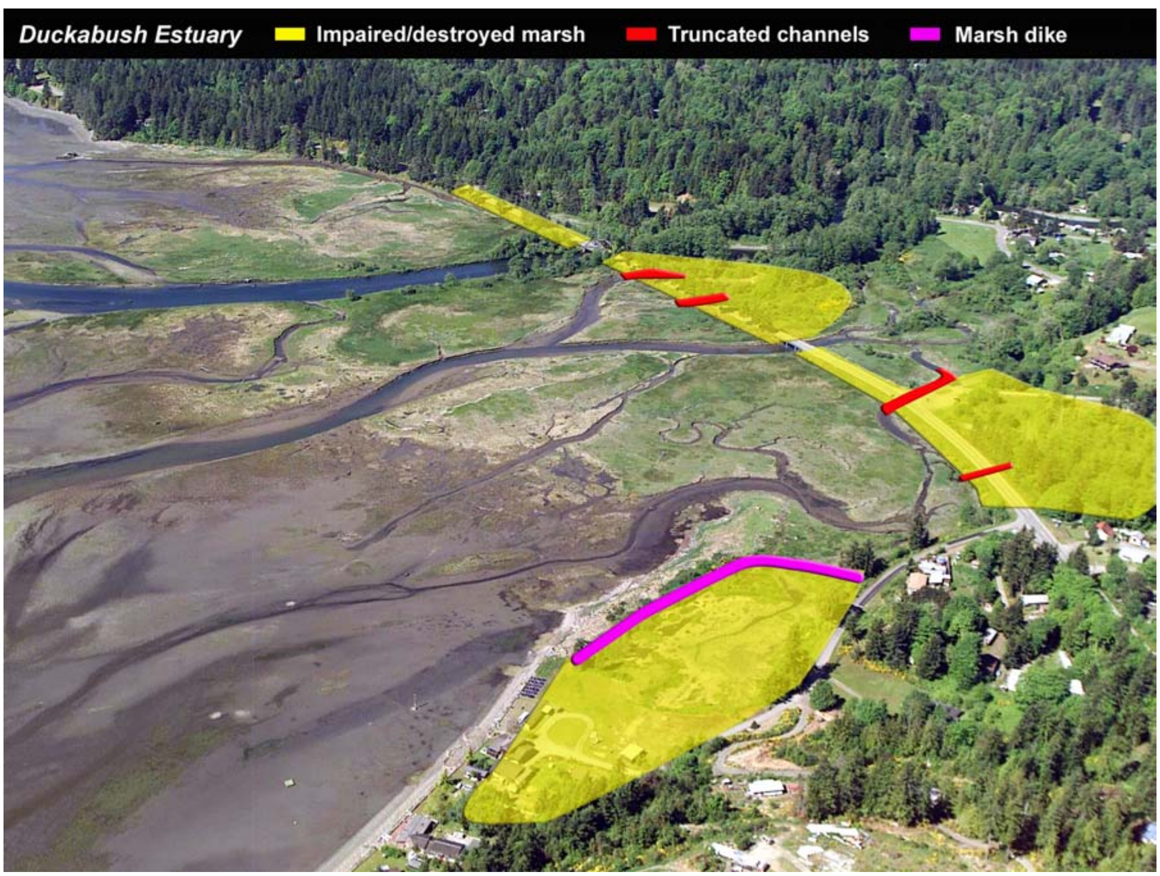

Figure 81. Duckabush Estuary, 2003. Graphic provided by Randy Johnson, WDFW.

A spit along the northwestern shoreline of the Duckabush estuary has been diked and filled and is predominantly lined with Scott's broom. A small creek flows through an undersized culvert into the northwest corner of the Duckabush estuary and should be bridged to allow more tidal access and future reestablishment of salt marsh habitat. The intersection of Highway 101 and Duckabush River Road interrupts a main tidal slough (Pierce Creek Slough) and eliminates historic salt marsh habitat. This intersection should be reconfigured to reconnect the slough. A northern distributary channel has been disconnected from the mainstem and should be reconnected. Approximately 13 acres of salt marsh habitat has been truncated by Highway101 to the north of the mainstem channel. The existing mainstem bridge should be lengthened to span the slough to the north of the channel and to reconnect the salt marsh habitat. To the south of the mainstem channel, approximately 3.6 acres of an historic 6-acre salt marsh have been eliminated (Ecology 2001; TAG 2003).

Figure 82. McDaniel Cove, 2000. Ecology oblique photo #102708.

A large jetty within McDaniel Cove has been in place since 1942 and was perhaps the beginning of a roadbed to avoid the sharp curve into the head of the inlet. Since this is obsolete, it should be removed. Approximately 0.7 acre of historic salt marsh has been filled at the head of the bay for Highway 101 as well as a front yard for a home site and should be removed to restore the lost salt marsh habitat (Ecology 2001; TAG 2003).

Figure 83. Fulton Creek, 2000. Ecology oblique photo #102616.

Riprap and fill have been placed along the north side of the Fulton Creek estuary, which has eliminated the historic islands of salt marsh and should be removed. Highway 101 fill has also eliminated an historic salt marsh and disconnected it from the salt marsh habitat upstream of the highway. The bridge span over Fulton Creek should be lengthened and the fill removed to restore salt marsh habitat. A house with fill behind a riprap bulkhead extends into the intertidal zone just to the south of the delta of Fulton Creek. A large amount of fill behind riprap extends into the intertidal zone along the south shore of a small, unnamed tributary to Hood Canal to the south of Fulton Creek. This parking area, owned by WDFW for recreation, should be relocated away from the intertidal area (Ecology 2001; TAG 2003).

Riparian Loss

SR101 has eliminated riparian areas throughout this section where the road has been placed close to the shoreline and riprap has been used to protect the roadway. Invasive species have taken the place of native vegetation. A programmatic management plan to eliminate exotic species and reestablish native vegetation along SR101 should be implemented. Riparian vegetation has been eliminated at a WDFW access site between Fulton Creek and Triton Cove. Triton Cove State Park is also devoid of native riparian vegetation (TAG 2003).

Action Recommendations

- Reestablish historic tidal connection
- Improve the connection of the small creek flowing through an undersized culvert into the northwest corner of the Duckabush estuary
- Remove the dike along the north side of the Duckabush estuary along Robinson Road
- Elevate SR101 across the Duckabush estuarine delta to restore tidal connectivity and the reestablishment of native vegetation
- Reconfigure intersection of SR101 and the Duckabush River Road to reconnect Pierce Creek Slough
- Reconnect northern distributary channel with the Duckabush River
- Restore Pierce Creek and tidal connectivity by bridging Shorewood Road and restoring riparian function
- Remove jetty fill in McDaniel Cove
- Remove residential and transportation fill at the head of McDaniel Cove to restore salt marsh habitat
- Remove fill along the north side of Fulton Creek estuary to restore salt marsh and island habitat
- Lengthen bridge span over Fulton Creek to restore historic salt marsh habitat
- Remove armor forming old boat launch and basin west of SR101
- Remove parking lot away from intertidal zone and restore riparian function on WDFW property along the south shore of an independent tributary that lies between Fulton Creek and Triton Cove and reestablish riparian vegetation
- Remediate stormwater and bilge water on state park access at Triton Cove
- Reestablish native plants on state park access at Triton Cove
- Combine multiple docks into one on state park access at Triton Cove
- Remove abandoned creosote pilings at Triton Cove

TRITON HEAD THROUGH HAMMA HAMMA

Five drift cells and three areas of no appreciable net shore drift are between Triton Head and the rural community of Eldon along the southwestern shore of the Hamma Hamma estuary.

Drift Cell and Biota Background

For approximately 1 km along the eastern side of Triton Head, the shore is primarily basalt of the Crescent Formation, which extends into deep water, resulting in no appreciable net shore-drift (Schwartz 1992). Houses line the shoreline and approximately 50% of the riparian zone is impacted (Ecology 2001).

The first drift cell, Ecology designation MA-1-3, in this segment begins south of Shaerer Creek where a small delta has formed at the northern end of a series of basalt outcrops which extend into deep water and terminates along the south side of Triton Head. Northeastward from the delta, there is a sediment size decrease from predominantly large pebbles to smaller pebbles. Small groins along a bulkhead have sediment accumulated on the southwest sides. At Beacon Point, a small rural development, a boat ramp, which extends about 30 m across the upper shore, has blocked sediment so that there is now a vertical offset of the shore of about 1 m and a horizontal offset of nearly 10 m. The Beacon Point development is built in part upon the delta of Schaerer Creek. The beach immediately north of the delta appears somewhat eroded and the sediment again decreases in size gradationally to a sand-granule-pebble spit built northeasterly at the sector terminus. The spit encloses a lagoon on the south side of Triton Head. Drainage from the lagoon is at the northeast end of the spit abutting the basalt which forms the headland (Schwartz 1992). The water level in the pond is controlled by a tide gate for swimming which creates water quality problems and fish stranding impacts. The pond should be allowed to return to salt marsh (TAG 2003). There do not appear to be appreciable amounts of sediment bypassing the southern point of Triton Head (Schwartz 1992). Sediment source varies from alongshore of moderate abundance, to fluvial influence of Shaerer Creek to a scarce amount from backshore along the southern shore of Triton Head. Salt marsh habitat in the vicinity of Shaerer Creek has been reduced from that indicated in historic maps. The intertidal zone varies between 17 feet and 95 feet with patches of fucus and barnacles along the beach (WDNR 2001). Sand lance spawn within this drift cell (Penttila 2000).

An area of no appreciable net shore drift is between the origin of the drift cell to the north and the terminus of the drift cell to the south (Schwartz 1992). The rocky basalt shoreline has been largely undisturbed. A cement and riprap seawall along the entire length of Robbinswold Girl Scout Camp appears to be above the ordinary high water line. The intertidal zone varies between 10 and 15 feet with patches of fucus and barnacles (WDNR 2001).

This next 0.5 km drift cell, Ecology designation MA-1-4, originates immediately south of the delta of a small stream in the vicinity of Mike's Beach Campground, and terminates to the north at the southern end of a series of basalt outcrops which effectively block sediment movement. Northward drift is indicated by a sediment size decrease in that direction, by a large sediment accumulation south of a groin and erosion north of that groin at a local resort, and by a small intermittent stream which is diverted northward (Schwartz 1992). Sediment source is predominantly alongshore with some fluvial input, all of moderate abundance. The intertidal zone varies between 20 and 87 feet with patches of focus, barnacles and lichen (WDNR 2000). Highway fill onto the intertidal zone at a small stream crossing at Mike's Beach Campground should be replaced with a larger culvert or a bridge (TAG 2003).

A very short sector of southward drift from the divergence zone of the northern drift cell to the small rocky headland to the south, Ecology designation MA-1-5, is indicated by a decrease in sediment size to the south and by piling of sediment on the north sides of portions of the headland. South of the small headland, cliffs of basalt of the Crescent Formation prevent any appreciable shore-drift (Schwartz 1992). Sediment source is backshore from steep cliffs in moderate abundance. The intertidal zone is only one foot wide with patches of fucus and lichen (WDNR 2001).

The next drift cell, Ecology designation MA-2-1, extends across the delta of Waketickeh Creek providing fluvial sediments of moderate abundance (WDNR 2000). Northeastward drift is indicated by accumulations of sediment south of obstacles. The creek appears to have originally been diverted northward but it has been artificially channelized and the delta, altered by development, obscures the original configuration. At both ends of the sector are cliffs of basalt, which prevent appreciable sediment bypass (Schwartz 1992). The broad delta fan/intertidal zone is approximately 110 feet wide with salt marsh habitat and patches of fucus along the shoreline (WDNR 2001).

Drift in the next small sector, Ecology designation MA-2-2, is northeastward from the north side of the Hamma Hamma River delta to the basalt cliffs immediately north of Cummings Point. Accumulations of sediment south of obstacles and decreasing sediment size northward indicate drift to the northeast (Schwartz 1992). The sediment source is alongshore in moderate abundance. The intertidal zone is approximately 25 feet with patches of focus and barnacles along the shoreline (WDNR 2000).

The inner area of the Hamma Hamma River delta is marshy with numerous older channels of the river. There does not appear to be appreciable shore-drift across this area (Schwartz 1992). The sediment source is fluvial and abundant. The sand flat/intertidal zone is approximately 510 feet with patches of barnacles and salt marsh throughout (WDNR 2001).

The main channel today was a secondary channel historically. It has been straightened, channelized, diked and dredged. The freshwater has been routed away from the shellfish beds. The historic secondary channel, now the mainstem, was once an extended salt marsh with a spit crossing the mainstem. A remnant dike is built on the spit. Pilings used to support the dike have become exposed as the dike has eroded away. A large bulkhead with wing walls and fill now accommodate a shellfish facility and parking lot at the base of the historic spit. Sediment is recruiting to the south of the facility. Aquaculture activities maintain a large footprint within the bay (TAG 2003).

Shoreline Armoring

Approximately 1,625 meters of the shoreline within this segment, or 15%, have been armored (Hirschi et al. 2003). These numbers are considered conservative. Combined armoring from transportation and residential development effectively disrupts most backshore sediment recruitment (TAG 2003). The shoreline is armored between basalt outcroppings to the south of Triton Head, creating an artificially straight line across the shoreline. A concrete bulkhead protects Beacon Point picnic area as well as extended front yards of homes. Riprap and concrete bulkheads line the entire shoreline of Robbinswold Girl Scout Camp but appear to be above the ordinary high water line. A concrete and riprap seawall lines the shoreline of Mike's Beach Resort and intrudes into the intertidal zone. Both the north and south sides of the Wacketickeh estuary are armored.

Extensive diking and armoring in the lower Hamma Hamma River has caused an historic secondary channel to become the mainstem. All armoring should be removed to allow the river to move back to its original channel and all tidal/stream channels should be restored (TAG 2003).

Overwater Structures

A dock with a boat house and rail launch extend out over the basalt outcroppings to the south of Triton Head. A long wharf with a boathouse extends onto the beach at Robbinswold Girl Scout Camp. Remnant pilings are also in the vicinity. A long pier with a float is partially placed on fill at Mike's Beach Resort and should be redesigned to eliminate the fill for better sediment transport.

Ramps/Rail Launches

A dock with a boat house and rail launch extend out over the basalt outcroppings to the south of Triton Head. Two marine rails are associated with Beacon Point but do not appear to interrupt sediment drift. A boat ramp associated with a long dock and boathouse is at Robbinswold Girl Scout Camp. A steep boat ramp is located at Mike's Beach Resort. There are three boat ramps between Mike's Beach Resort and the Wacketickeh River.

Stormwater/Wastewater

An historic salt marsh with a small open pocket al.ong the south shore of Triton Head has been dredged and deepened into a swimming pond. Management of a tide gate at the outlet creates water quality problems and strands fish. Historically this was a salt marsh with a small open water pocket and it should be returned to salt marsh habitat. Creosoted pilings at Beacon Point should be removed (TAG 2003).

Landfill

Beacon Point, a rural residential community has filled a 1.3 acre salt marsh with houses and picnic areas. The picnic area should be relocated to allow further tidal exchange within the Schaerer Creek estuary and to restore lost salt marsh habitat. The homes and associated bulkhead to the south of the picnic area should also be relocated to reclaim shallow water habitat for juvenile salmonid migration. Fill associated with a pier at Mike's Beach Resort should be removed. A long bulkhead protecting several cabins on fill at Mike's Beach Resort impacts juvenile salmon migration. To provide a shallow water migration corridor, the bulkhead and cabins should be relocated landward. The north side of the Wacketickeh Creek was once a salt marsh with open water and grassland and has been filled and converted to a home site and old vehicle storage/wrecking yard. The Highway 101 bridge across Wacketickeh Creek should be expanded to reestablish lost tidal channels (TAG 2003).

Figure 84. Wacketickeh Creek Estuary, 2000. Ecology oblique photo #102110

Approximately 13% of the estimated 368.5-acre historic Hamma Hamma delta is diked in three areas, accounting for a loss of 48 acres of juvenile salmonid rearing habitat. One filled area in the outer, southern corner of the delta accounts for a loss of 3.2 acres (1% of historic delta habitat). An estimated 2.4 acres of the mainstem distributary channel (where it crosses the outer intertidal area) has been dredged, and at least seven areas (2.2 acres) of aquaculture or other modifications of the delta surface are apparent from analysis of current aerial and oblique photos. Three jetties or pile dikes, totaling 0.4 miles in length, are evident in the delta. In addition, eight road and causeway segments, totaling 1 mile in length, transect the delta, the largest of which is t he Highway 101 causeway that has caused a direct loss of habitat and restricted tidal action and fish movement across the delta (WDFW and PNPTC 2000). WSDOT should replace the Highway 101 causeway/bridge with an elevated structure all across the delta to allow reestablishment of tidal channels and salt marsh habitat. Where dikes have failed, channels are beginning to reestablish (TAG 2003).

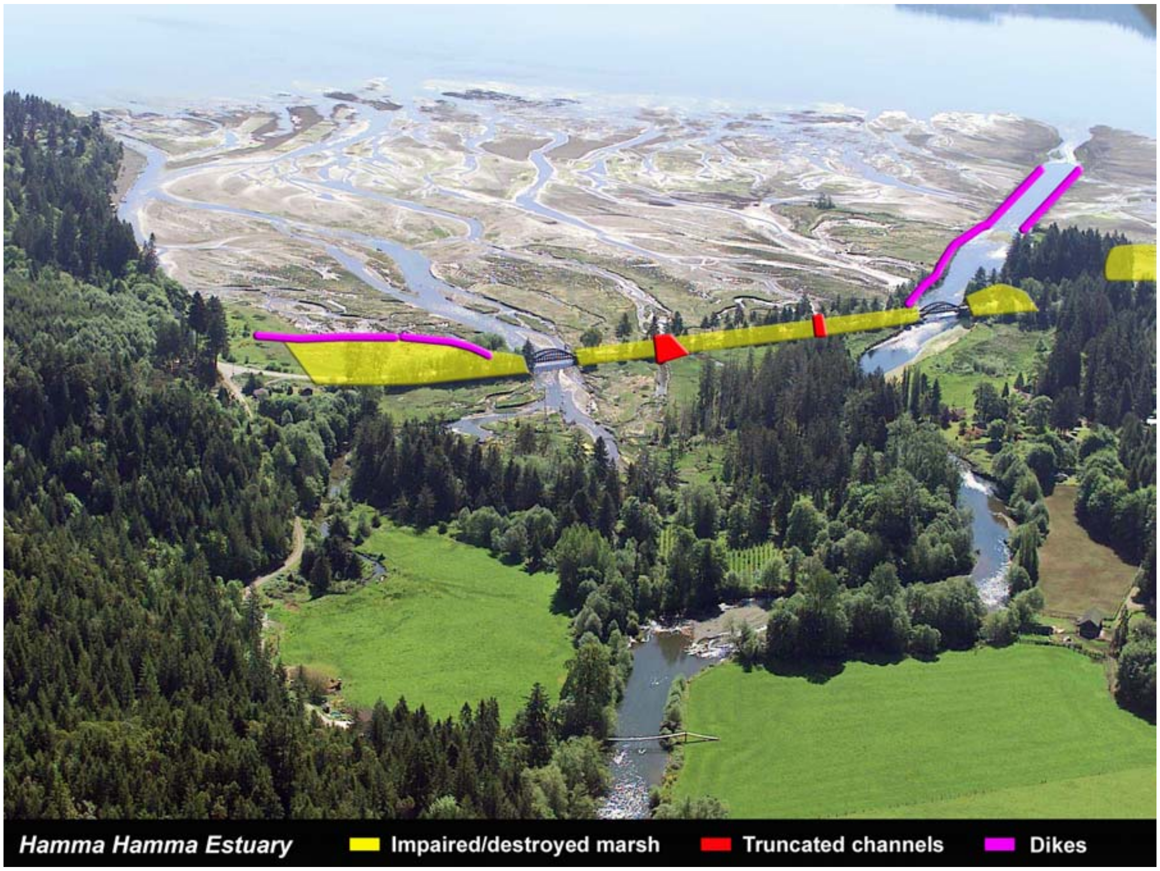

Figure 85. Hamma Hamma Estuary, 2003. Graphic provided by Randy Johnson, WDFW.

The apparent isolation of the north bank estuarine salt marsh from the main river by dredging and dike/road causeway construction at the river mouth has eliminated the connectivity of the river with this critical rearing habitat. As a result, outmigrating fry/smolts are forced directly into deepwater habitat to face predation risks and must reenter the marsh from the east from Hood Canal (WDFW and PNPT Tribes 2000). To restore juvenile rearing habitat, the dike along the north, the dike along the mainstem and other minor dikes should be removed to regain lost salt marsh habitat and to restore estuary function. Once the existing mainstem dikes are removed, monitoring the historic sand berm will be important for its recovery. The pilings on the spit should be removed. There is additional salt marsh loss to the south of the existing mainstem. One small marsh is adjacent to the river and the other is larger and farther south with aquaculture infrastructure on it. The fill that protects the parking a lot should be removed to restore salt marsh habitat. Approximately one acre to the south of the Hamma Hamma shellfish facility has been filled and is overrun with exotic vegetation, which should be removed and planted with native conifers and shrubs (TAG 2003).

Riparian Condition

Approximately 50% of the riparian zone along the eastern side of Triton Head has been replaced with home sites and yards. Approximately 40% has been removed between Triton Head and Schaerer Creek. All the riparian vegetation has been removed within the

Beacon Point development but has been left intact between Beacon Point and Robbinswold where a small amount has been removed for a lodge and some outbuildings. The riparian zone between Robbinswold and Mikes Beach Resort is intact as is the area between Mike's Beach and the Wacketickeh. The original grassland at the Wacketickeh has been replaced with rural residence and vehicle storage. The riparian zone between the Wacketickeh and the Hamma Hamma is intact with the exception of some houses and associated view clearing at Cummings Point (TAG 2003).

Action Recommendations

- Remove tide gate and culvert and return a swimming pond along the southern side of Triton Head to salt marsh habitat, restore beach berm and limit impacts to fish
- Restore slat marsh and intertidal habitat at the Beacon Point community picnic area by removing bulkheads and fill
- Relocate houses and associated bulkheads that extend into the intertidal zone at Beacon Point to restore juvenile migration corridor and sediment transport
- Remove creosote pilings at Beacon Point
- Redesign dock at Mike's Beach Resort to eliminate fill and reestablish shallow water migration corridor and decrease shading of eelgrass
- Relocate cabins and associated bulkhead at Mike's Beach Resort to reestablish juvenile migration corridor and sediment transport
- Extend SR101 creek crossing at Mike's Beach Campground
- Remove fill and relocate structures along the north side of the Wacketickeh estuary
- Expand the bridge across the Wacketickeh to reestablish the lost tidal channel
- Replace SR101 causeway/bridge with an elevated structure across the entire Hamma Hamma delta
- Remove all levees/dikes and armoring, particularly the mainstem dike, the dike along the north side of the estuary, and other minor dikes to restore historic mainstem channel, tidal channels and estuary function
- Remove bulkhead and fill that forms an unused part of a parking lot at the Hamma Hamma shellfish facility to restore salt marsh habitat
- Remove pilings from existing sand spit
- Remove exotic vegetation in the vicinity of the Hamma Hamma shellfish facility and replant with native conifers and shrubs

HAMMA HAMMA THROUGH LILLIWAUP

Four drift cells are between the Hamma Hamma River at Eldon and Lilliwaup Bay. Included also in this section is a discussion of the terminus of a more southern drift cell that ends in Lilliwaup Bay.

Drift Cell and Biota Background

The first drift cell in this section, Ecology designation MA-2-3 and MA-3-1, begins to the south of Jorsted Creek and moves northward to the southern mouth of Hamma Hamma Bay at Eldon. South of Jorsted Creek the sediment source is alongshore in moderate abundance with patches of fucus and barnacles along the 25-foot wide sand beach bordered by basalt outcroppings (WDNR 2001; TAG 2003). Jorsted Creek, an abandoned log dumpsite, has been channelized and diverted to the north. Historic tidal channels are gone as is a large spit feature. Approximately 4.25 acres of salt marsh have also been filled with SR101 fill, buildings and roads (TAG 2003). A sandy prograding beach is developing on the south side of the delta of the stream and several sand bars are moving up onto the delta from the south (Schwartz 1992). Here the sediment source is fluvial of moderate abundance and the intertidal zone is 170 feet with patches of fucus and barnacles and aquaculture activities (WDNR 2001). North of the stream delta the beach is narrow and the sediment coarse. The beach widens northward and the sediment-size decreases until the south side of the Hamma Hamma River delta where a sandy prograding beach is developing , similar to the one at Jorsted Creek, and again numerous bars are moving up onto the delta. Drift terminates at the present river channel which has been channelized with long riprap jetties that truncate old spits and which originally diverted the river northward (Schwartz 1991).

Southeastward drift from the divergence zone of the previous drift cell to Ayock Point, Ecology designation MA-3-2, is indicated by a slight accumulation of sediment northwest of a boat ramp at the Ayock Point development and by a size decrease of the sediment with a corresponding increase of beach slope. Ayock Point is a cuspate spit formed as a result of drift cell convergence from the north and south (Schwartz 1991). The sediment source is alongshore in moderate abundance. The intertidal zone is approximately 30 feet wide with patches of barnacles and eelgrass along the shoreline (WDNR 2001).

This relatively long drift sector, Ecology designation MA-3-3 and MA-4-1, is approximately 7 km long and originates at a broad divergence zone, a 115-feet wide intertidal zone on the north side of Lilliwaup Bay (Schwartz 1991), where fluvial sediments are moderately abundant. The intertidal zone narrows to approximately 30 feet in width along the majority of the shoreline with the exception of the Eagle Creek delta where the intertidal zone extends to 115 feet in width (WDNR 2001). This drift cell terminates at Ayock Point. At the north side of the entrance to Lilliwaup Bay, a wave cut platform is exposed through a thin layer of cobbles and boulders (Schwartz 1991). Northeasterly shore-drift along the majority of the segment is predominantly alongshore in scarce to moderate abundance (WDNR 2001) and is indicated by sediment accumulations on the southwest side of numerous logs, groins, and bulkheads, and by a decrease of sediment size and beach widening toward the northeast (Schwartz 1991). An active feeder bluff to the south of Eagle Creek should be protected (TAG 2003). At Eagle Creek, where sediments are fluvial in moderate abundance (WDNR 2001), the highway is built upon what appears to have been a spit, which had enclosed a lagoon and diverted stream flow northward. A small spit immediately south of Ayock Point diverts stream drainage northward (Schwartz 1992). An intact remnant salt marsh with a walkway through the center should be preserved at Ayock Point (TAG 2003). The deltaic deposition by Ayock Creek, which has been relocated to the south of its historic channel, has formed a wide beach and tideland south of Ayock Point, whereas on the north side, the beach descends steeply to a small boat anchorage. Consequently, even though more material may move to the point from the south, the north side is more typical of the cuspate spit model. The base of the bluff along most of this segment is armored with riprap in an attempt to prevent erosion and stabilize the steep upper slopes, which have frequently failed (Schwartz 1991). Patches of fucus and barnacles are found along the predominantly sandy shoreline with salt marsh habitat and dune grasses near the origin of this drift cell (WDNR 2001).

The next southern drift cell, Ecology designation MA-4-2, is within Lilliwaup Bay, extending from the divergence zone along the north side of the bay entrance to the highway bridge at the head of the bay. Drift northwest into the bay is indicated by a sediment size decrease and a slowly prograding beach on the bayside of the highway bridge footing. Lilliwaup bay originally extended farther inland, but construction of the bridge has isolated the portion west of the highway and it is not now affected by shore-drift. The Lilliwaup River delta, upstream of the bridge, appears to be filling in with sediment at a rapid rate (Schwartz 1991). This is due to the constriction of SR101 and resulting sediment transport restriction (TAG 2003). Sediment source is fluvial in moderate abundance with a wide 115-foot intertidal zone at the cell origin diminishing to approximately 30 feet at the terminus. High salt marsh habitat and tide flats with patches of barnacles are found along the shoreline (WDNR 2001). Lilliwaup Creek is a two channel system that is funneled into one channel under the SR 101 bridge where sediments have accumulated (TAG 2003).

The final drift cell, Ecology designation MA-4-3 and MA-5-1, in this segment is a northern end and terminus of a drift cell to the south. Drift in the north is indicated by sediment accumulations south of numerous groins and by a general size decrease of the sediment to the north. The terminus is marked by a slowly prograding beach developing at the south side of the highway bridge footings at the head of Lilliwaup Bay (Schwartz 1991). Sediment source is fluvial in moderate abundance with an intertidal zone of approximately 115 feet in width. Barnacles and fucus dot the sandy flat and a salt marsh is present within this segment.

Shoreline Armoring

SR 101 interrupts sediment recruitment from an eroding bluff to the south of Eldon in addition to several other areas. Armoring protects fill associated with a small parking lot/access to an abandoned log storage site to the north of Jorsted Creek. Armoring protects fill associated with residential development to the south of Jorsted Creek. Riprap along the east side of SR101 interrupts sediment recruitment from eroding feeder bluffs that could feed Jorsted estuary. In lieu of moving the road, the TAG suggests beach nourishment for this segment only as well as exotic species removal and revegetation with natural species along the roadside. A riprap triangular extension with fill into the intertidal zone to the north of Eagle Creek should be removed. It connects with a long riprap segment to the north that protects SR101 but does not appear to encroach into the intertidal area. The shoreline is armored north of the mouth of Lilliwaup Bay to protect SR101 where it interrupts sediment recruitment from eroding bluffs along the west side of the highway. Approximately 5,742 meters of the shoreline in this segment, or 35% of the shoreline, are armored (Hirschi et al. 2003). These numbers are considered conservative. Combined armoring from transportation and residential development effectively disrupts most backshore sediment recruitment (TAG 2003).

Overwater Structures

A large pier and float, apparently for the community use, are along the north side of Ayock Point.

Ramps/Marine Rail Launches

A community boat launch is along the north side of Ayock Point and is a good example of shared boat access to the water. There are two railway launches associated with a housing/condominium complex between Ayock Point and Eagle Creek. A private boat launch is further to the south but does not seem to be interrupting sediment drift. A rail

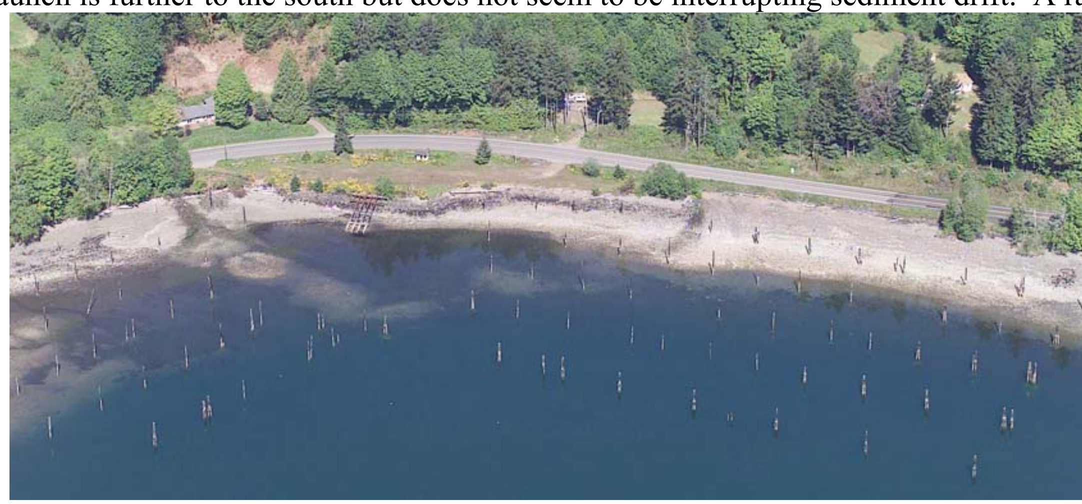

Figure 86. Creosoted pilings and log skid apparatus to north of Jorsted Creek, 2000. Ecology oblique photo # 101538.

launch is associated with a house and garage to the north of Carroll/Cabin Point. There are five boat launches at Carroll/Cabin Point, two of which could be consolidated as they are at the same house. A community boat launch should be encouraged at this site.

Stormwater/Wastewater

An excess of 100 creosoted pilings at Jorsted Creek were once part of a log storage site and have become roost sites for predatory birds. This number of roost sites exceeds the number that would occur naturally, increases the opportunities for salmonid predation and could present water quality problems due to the creosote.

Figure 87. North side of Ayock Point, 2000. Ecology oblique photo #101442.

A densely inhabited residential development at Ayock Point could present water quality problems. The TAG suggests investigating septic systems, stormwater runoff and herbicide/pesticide use in the area.

Landfill

An undeveloped parking lot fill/riprap and log skid apparatus immediately north of Jorsted Creek should be removed. Jorsted Creek has been channelized and moved to the north of its historic estuary. Approximately 4.25 acres of salt marsh habitat has been filled for SR101 and residential development. Historic tidal channels and a large spit feature have also been eliminated. An action recommendation is to move SR101 to the west and purchase historic estuary and salt marsh property to accommodate fill removal and salt marsh restoration. Jorsted Creek could then be repositioned to its historic configuration.

Figure 88. South side of Ayock Point, 2000. Ecology oblique photo #101424.

A bulkhead and house at the north end of the north side of Ayock Point extends into the intertidal zone and should be removed. A 6-acre salt marsh with a tidal lagoon has been filled and an historic spit feature has been degraded at Ayock Point. A bulkhead and fill along the south shore of Ayock Point extends into the intertidal zone and should be removed. A minimum of five houses should be purchased or relocated to restore salt marsh and beach and to restore juvenile fish migration. An additional 4 houses to the north of Ayock Creek are on fill and should also be removed or relocated. A small salt marsh to the south should be expanded to its historic extent to include the remnant lagoon with reestablishment of the tidal connection at the northern end of a spit. Further to the south a house is built behind a bulkhead and on fill that extends into the intertidal zone and should be removed or relocated landward. Further to the south, two residences with a long bulkhead, stairways, rail launches and bulkhead reinforcements extend into the intertidal zone and should be removed. In addition, the condominium complex interrupts backshore sediment from a feeder bluff. A riprap triangular extension with fill into the intertidal zone to the north of Eagle Creek should be removed.

At Eagle Creek, an historic salt marsh has been dredged and converted to a freshwater pond. The salt marsh was protected by a spit feature, which has now become SR 101. The historic tidal channel, which was once the saltwater connection to the lagoon, has been eliminated. The bridge span over Eagle Creek runs along the historic grassland spit with some additional fill and with riprap along the left bank. The SR101 bridge span should be extended and fill should be removed to reestablish salt marsh habitat and tidal connection to the pond. A bulkhead with fill to the south of Eagle Creek is intruding onto the intertidal zone and should be removed. A 0.5-acre salt marsh to the north of Carroll/Cabin Point has been impacted. The remaining salt marsh should be conserved and enhanced. The shoreline has been fragmented and there is some intrusion into the intertidal zone by the housing development at Carroll/Cabin Point. A bulkhead with a large deck extends into the intertidal zone to the south of the more intense development of Carroll/Cabin Point and should be removed.

Figure 89. Eagle Creek Estuary, 2000. Ecology oblique photo #101254.

Lilliwaup Creek is a two-channel system that is funneled into one channel under the SR101 bridge where sediments have accumulated. The TAG suggests expanding the bridge span and removing the fill to accommodate both channels and tidal flows and to restore estuary function. The area upstream of the bridge was historically mudflat, but is filling in due to the bridge constriction and is becoming vegetated. Houses along the north side of SR101 are placed on fill that has eliminated approximately 0.7 acres of salt marsh habitat and wetlands. The fill should be removed and the houses removed or relocated. Dikes creating a trout pond within the estuary upstream of SR101 should be removed to restore saltwater access to the historic estuary boundaries. Structures, roads and dikes that are now within the historic estuary should be set back and the access bridge should be expanded to allow full estuary restoration. This will avoid future problems with sediment accumulation outside the diked areas, which will eventually be lower in elevation and subject to flooding and erosion problems (TAG 2003). A creek entering the estuary along the right bank is entirely within a culvert and should be day-lighted all the way to the falls.

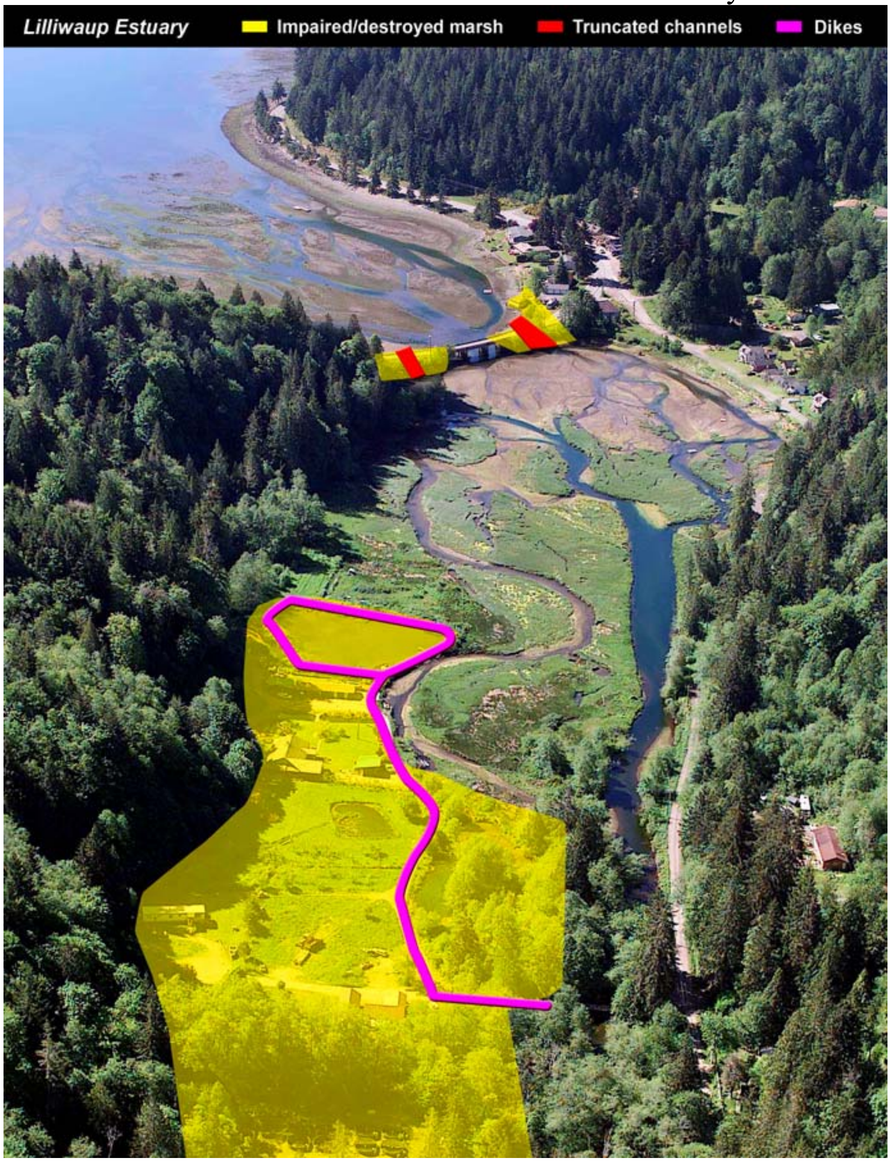

Figure 90. Lilliwaup Estuary, 2003. Graphic provided by Randy Johnson, WDFW.

Riparian Loss

Immediately to the south of Eldon, SR 101 has eliminated a riparian zone, which is now dominated by Scot's broom, an exotic invasive species. The conditions improve moving south until Jorsted Creek, where SR101 and a parking lot have eliminated the riparian zone and Scot's broom has invaded the area to the north and to the south. Sediment supply from a feeder bluff has been interrupted by SR101. A riparian zone, although narrow and dysfunctional in places, continues to Ayock Point development, where the riparian zone has been removed for high impact housing. Southward from Ayock, the riparian zone is intact except where houses and yards interrupt the connectivity.

Immediately to the north of Eagle Creek the riparian zone has been removed for a view four houses west of SR101. The riparian zone is sparse at Eagle Creek and to the south. Trees have been removed at the housing development at Carroll/Cabin Point as is typical of most of this region. A very thin band of vegetation extends north of Lilliwaup Bay between SR101 and the shoreline. The riparian zone along the south side of Lilliwaup Bay has been removed along the western end and is very sparse toward the eastern end.

Figure 91. Sediment supply interruption by SR 101 south of Jorsted Creek, 2000. Ecology oblique photo #101450.

Data Needs

- Investigate shellfish harvest and aquaculture impacts to juvenile fish migration and nearshore habitat at Eagle Creek

Action Recommendations

- Remove creosote pilings to the north of Jorsted Creek
- Remove armoring, fill and log skid apparatus to the north of Jorsted Creek
- Relocate SR 101 to the west at Jorsted Creek, acquire estuary and restore Jorsted Creek to equilibrium location
- Restore sediment supply from feeder bluff near Jorsted Creek
- Acquire and remove bulkhead and house at north end of north side of Ayock Point
- Acquire and remove bulkhead along south part of south side of Ayock Point
- Acquire and remove four houses north of Ayock Creek to restore channel to former location
- Preserve remnant salt marsh and restore historic salt marsh to include remnant lagoon and accretion spit and reestablish tidal connection at northern end of spit to the south of Ayock Creek
- Purchase and remove bulkhead, house and fill to the between Ayock and Eagle Creek
- Purchase and remove bulkhead/fill and residences between Ayock and Eagle Creek to reestablish shoreline processes, backshore sediment recruitment and juvenile migration corridor
- Remove abandoned, triangular bulkhead and fill to the north of Eagle Creek
- Extend SR101 bridge and remove fill to reestablish accretion spit, salt marsh and tidal connection to the lagoon at Eagle Creek
- Remove bulkhead and fill between Eagle Creek and Carroll/Cabin Point to preserve and enhance salt marsh

- Extend SR101 bridge span and remove shoulders/fill at Lilliwaup
- Remove fill and development seaward of southern bridge abutment of SR101 at Lilliwaup to reestablish salt marsh habitat
- Remove trout pond diking, set back structures and roads and expand access bridge within Lilliwaup estuary west of the SR 101 bridge
- Daylight the creek to the falls on the right bank of Lilliwaup estuary west of the SR 101 bridge

LILLIWAUP BAY TO UNION

Lilliwaup Bay to Union begins at the southern mouth of Lilliwaup Bay and extends southward to include the smaller drainages along the west side of Hood Canal and the Skokomish River Delta. Five drift cells and three sections of no appreciable net shore drift are within this segment.

Drift Cell and Biota Background

The first section of net shore-drift, Ecology drift cell number MA-4-3 and MA-5-1, originates at the delta of Sund Creek, moves toward the north and terminates along the southern shore of Lilliwaup Bay (Schwartz 1991). Sediment accumulations south of groins in the delta area indicate northerly drift. In addition, distinctive shale fragments from beds exposed along the northern portion of section 31 become gradationally smaller northward (Schwartz 1991). Sediment source is alongshore in moderate abundance. The intertidal zone ranges between 12 feet to 95 feet near the origin. Patches of barnacles, fucus and lichen are found along the shoreline (WDNR 2001).

South of the previous segment, cliffs extend into deep water and prevent any appreciable shore-drift (Schwartz 1991). The intertidal zone width averages about 15 feet. A moderate amount of sediment is found along the sand and gravel shoreline, as well as patches of fucus and lichen (WDNR 2001).

Northward drift in the next sector, Ecology drift cell designation MA-5-2, originates farther south and continues northeastward to Sund Rocks where it is blocked by an outcrop of rock of the Crescent Formation. Miller Point is also a natural rock outcrop. Much of the shore along this segment, between Miller Creek and Clark Creek, is riprap and fill pushed onto the shore. A narrow beach is exposed at low tide, but other than a small accumulation of sediment at the south end of the bulkhead, there are no good geomorphic drift indicators along this stretch. North of Miller Creek, sediment accumulations occur on the south sides of several groins and a small stream about 400 m north of Miller Creek is diverted northward. A further indication of northerly drift is the sediment size decrease along the beach toward the terminus of this segment (Schwartz 1991). Sediment source is alongshore in moderate abundance at the drift terminus where the intertidal zone width is approximately 20 feet. Abundant fluvial sediments at the mouth of Miller Creek near the cell origin contribute to an increase in the intertidal zone to approximately 95 feet. Patches of fucus and barnacles and salt marsh habitat are found along the shoreline (WDNR 2001).

The next drift segment, Ecology's drift cell designation MA-6-1, begins in the Hoodsport area and continues north approximately 3.2 km. Sediment accumulation north of Finch Creek occurs at the south end of a bulkhead and the beach is eroding at the north end. The beach sediment is primarily boulders and cobbles with the exception of a small pebbly delta at the mouth of an intermittent stream. At this site an accumulation of pebbles is piled against the south side of a culvert (Schwartz 1991). Sediment source is alongshore in moderate abundance at the northern end of the cell but the source is fluvial in moderate abundance at Finch Creek near the origin. The intertidal zone ranges from

115 feet wide at the Finch Creek delta to 20 feet wide toward the north. Salt marsh habitat and patches of fucus and barnacles are found along the shoreline (WDNR 2001).

For about 1.5 km along the shore in the Hoodsport area, no clear shore-drift pattern emerges. Sediment accumulations are on either or both ends of the bulkheads. Whether this is partly due to waterfront development obscuring drift indicators or entirely because of an unusually lengthy divergence zone is unclear. However, there are clear indicators that north of Hoodsport net shore-drift is toward the north and at a short distance south of Hoodsport drift is toward the south (Schwartz 1991). Sediment is moderately abundant in this segment with an intertidal zone of approximately 22 feet in width. Patches of fucus and continuous barnacles are found along the shoreline (WDNR 2001).

Originating at the divergence zone in the Hoodsport area, net shore-drift in this sector, Ecology's designation MA-6-2, is southward and terminates at a discharge channel dredged from the Tacoma City Light hydroelectric generating station located 1 km south of Potlatch on the Skokomish Indian reservation. Southerly drift is indicated by a slight southward diversion of Hill Creek, a southward decrease of sediment size, accumulation of sediment north of groins, and a spit-like accreting beach oriented to the south of Potlatch (Schwartz 1991). Sediment source is fluvial in moderate abundance at the Hill Creek estuary near the drift cell origin, shifts to alongshore in moderate abundance moving southward, and becomes fluvial in moderate abundance at Potlatch State Park. The intertidal zone varies between 25 and 50 feet in width. Patches of salt marsh habitat, grassland, fucus and barnacles are found along the shoreline (WDNR 2001).

Within a short distance and within Annas Bay, shore-drift is obscured by the influence of flow from the Skokomish River. Sediment source is fluvial along the eastern and western shorelines of Annas Bay but is alongshore in the central part. Sediment abundance is only moderate. The intertidal zone ranges from 0 to 55 feet in width. Salt marsh habitat, dune grasses, and fucus are found along the shoreline (WDNR 2001).

The final drift cell in this short sector, Ecology designation MA-7-3, is southward, originating at a divergence zone south of the town of Union and terminating along the southeastern shoreline of Annas Bay. Sediment accumulations north of bulkheads and a boat ramp indicate drift to the south (Schwartz 1991). Sediment source is alongshore in moderate abundance. The intertidal zone varies from 0 feet in Annas Bay to 120 feet near the drift cell origin. Salt marsh habitat and patches of barnacles are found along the shoreline (WDNR 2001).

Shoreline Armoring

Armoring/riprap along SR101 encroaches onto the intertidal zone/mudflat at Little Lilliwaup estuary. In numerous stretches in this segment of Hood Canal, SR101 is close to the shoreline. Armoring/riprap has been placed along the shoulder to protect the highway, which often encroaches onto the intertidal zone and reduces the width of the riparian zone which is dominated by invasive species. The highway has eliminated backshore sediment sources throughout this segment and particularly in the southwestern most drift cell, MA-6-2. A 750-foot long bulkhead with supporting groins and houses to the south of the estuary fills approximately one acre of the intertidal zone. Homes to the south have been placed on bedrock with supplemented riprap with some intrusion onto the intertidal zone. Approximately 72% of the shoreline in Hoodsport is armored, primarily with bulkheads. The corresponding drift cell, MA-6-2, is bulkheaded along 45% of the shoreline (TAG 2003). These numbers are considered conservative. Combined armoring from transportation and residential development effectively disrupts most backshore sediment recruitment (TAG 2003).

Overwater Structures
A large boathouse and dock to the south of Little Lilliwaup estuary should be removed. The development in the vicinity of Miller Creek is good example of utilizing a single dock for community use. There are two docks further to the south. A small marina at Clark Creek has an extended platform along the shoreline, which could be reduced in width to decrease shade/predator impacts to juvenile fish migration (TAG 2003).

There are two piers associated with the Port of Hoodsport. The one that is not in use should be removed along with the creosoted pilings. A house to the south of Hoodsport is built almost entirely on pilings that extend over the intertidal zone quite a distance. The entire structure should be relocated shoreward. A dock and cabins associated with the old Rainier building extend over the intertidal zone. The buildings should be relocated landward. A house to the south of Hill Creek is partially built on pilings over the intertidal zone. Two docks are further to the south. Two additional docks are to the north (TAG 2003).

Two docks along the northern part of the Minerva Creek development should be removed and residents should use the community dock to the south. The grounding of docks should always be avoided, as in the case of the community dock, which should be remedied (TAG 2003).

Ramps/Marine Rail Launches
Boat ramps and two marine rail launches are associated with a small development to the south of Little Lilliwaup estuary. Six marine rail launches are associated with housing development to the south of Miller Creek. Approximately 20 rail launches are to the south of Hoodsport and could be consolidated. One marine rail launch is to the south of Hill Creek. Approximately 17 rail launches and three boat ramps are to the south of Hill Creek. There is one boat launch at the Tacoma Public Utilities (TPU) park/parking lot (TAG 2003).

Stormwater/Wastewater/Water Quality
Creosoted pilings that once supported a pier to the north of Hoodsport should be removed. Creosoted pilings that provide the foundation for a house to the south of Hoodsport should be removed and the house relocated shoreward. Seepage and ulva associated with houses to the south of Hill Creek could be indicators of failing septics and should be further investigated. A beach segment to the south of Hill Creek and to the north of the Tacoma Public Utilities (TPU) power plant has been cleaned. The use of herbicides/pesticides should be investigated at this site. Creosoted pilings associated with an abandoned log dumpsite to the north of TPU power plant should be removed. The

discharge from the TPU power plant confuses returning adult salmon as it is displaced Skokomish River water. The discharge flows present a physical/hydrologic barrier to fish migration and an interruption of eelgrass beds. An appropriate solution to restore natural processes at this site needs to be investigated and implemented. Creosoted pilings within the Skokomish Delta require removal (TAG 2003).

Figure 92. Undersized culvert, armoring, fill and boathouse at Little Lilliwaup Estuary, 2000. Ecology photo #100914.

Landfill

Armoring and fill associated with SR101 encroaches onto the intertidal zone at Little Lilliwaup estuary. The box culvert at this site restricts transport of debris and juvenile salmon migration when the tide is out and should be replaced with a bridge. The concrete bulkhead, fill and boathouse to the south of Little Lilliwaup Creek should be removed. Around the point a 750-foot long bulkhead and structures with groins that interrupt sediment drift fills approximately one acre of the intertidal zone and should be removed. An additional 1.7 acres of intertidal habitat has been replaced with bulkheads, fill and housing near a small stream to the north of Sund Creek (TAG 2003).

Figure 93. Bulkhead, fill, over-water structures and groins at Little Lilliwaup Point, 2000. Ecology oblique photo #100908.

The Sund Creek parking lot is on an historic salt marsh and should be relocated to the west side of SR101 to reestablish the salt marsh habitat. The dive shop is on natural outcroppings but extends out into the intertidal and should also be relocated to the other side of SR 101. Housing development has eliminated 3.4 acres of salt marsh due to development in the vicinity of Miller Creek. It appears that the intertidal zone is fenced off for each property. The riprap and fill to the north and to the south of the community center should be removed to restore salt marsh habitat, intertidal zones, sediment drift and juvenile fish migration corridors. The intertidal fill extends all the way to Clark Creek. The undersized culvert at Clark Creek restricts sediment and debris movement and should be replaced with a larger culvert or bridge (TAG 2003).

A bulkhead and fill with structures to the north of Hoodsport encroaches onto the intertidal zone and should be removed. The original concave bell shaped estuary of Finch Creek has been filled on both sides and the creek has been channelized into a cement flume as part of the Hoodsport Hatchery operations. The hatchery on the left bank should be relocated away from the shoreline to restore historic salt marsh habitat and nearshore processes. The right bank of the mouth should be restored to the historic estuary configuration. The structures between the Port of Hoodsport piers are built on intertidal fill that should be removed and the structures relocated. Houses on either side of a small natural area are built on fill that extends into the intertidal, forcing juvenile fish into deeper water and potential predator encounters during migration. The fill should be removed and the houses relocated. A zigzag structure associated with the houses on the south extends onto the beach and should also be removed. A zigzag bulkhead and an adjacent bulkhead, both with structures and fill should be removed to restore shallow water migration corridor and sediment transport (TAG 2003).

Figure 94. Tacoma Public Utilities powerhouse and park, 2000. Ecology oblique photo #100434.

An undersized culvert at Hill Creek that restricts estuary function should be replaced with a larger culvert or a bridge. The old Rainier buildings are built on fill and should be removed. An angular bulkhead with fill, houses and drains might not encroach onto the intertidal zone, but there are additional impacts, such as soil compaction and loss of a freshwater lens that could affect hydrologic and biotic processes (TAG 2003).

Cushman Powerhouse Park has been placed on fill and should be reconfigured to follow the historic shoreline with a riparian zone management program. The mouth of Minerva Creek runs under a development, which has eliminated the estuary, and should be day-lighted for fish access and estuary restoration. Potlatch State Park is located on eroding wood waste from an old pulp mill. The historic salt marsh with tidal channels has been replaced with park lawns. The fill should be removed to restore salt marsh habitat and tidal channels. Wetlands drain to the south of the parking lot. The historic tide channel at Enetai Creek extended upstream to the existing tribal fish hatchery but has been replaced with a concrete vault/tide gate for the fish trapping facility. The historic spit remains. The trapping facility should be redesigned and reconstructed to allow better estuary function and tidal channel connectivity (TAG 2003).

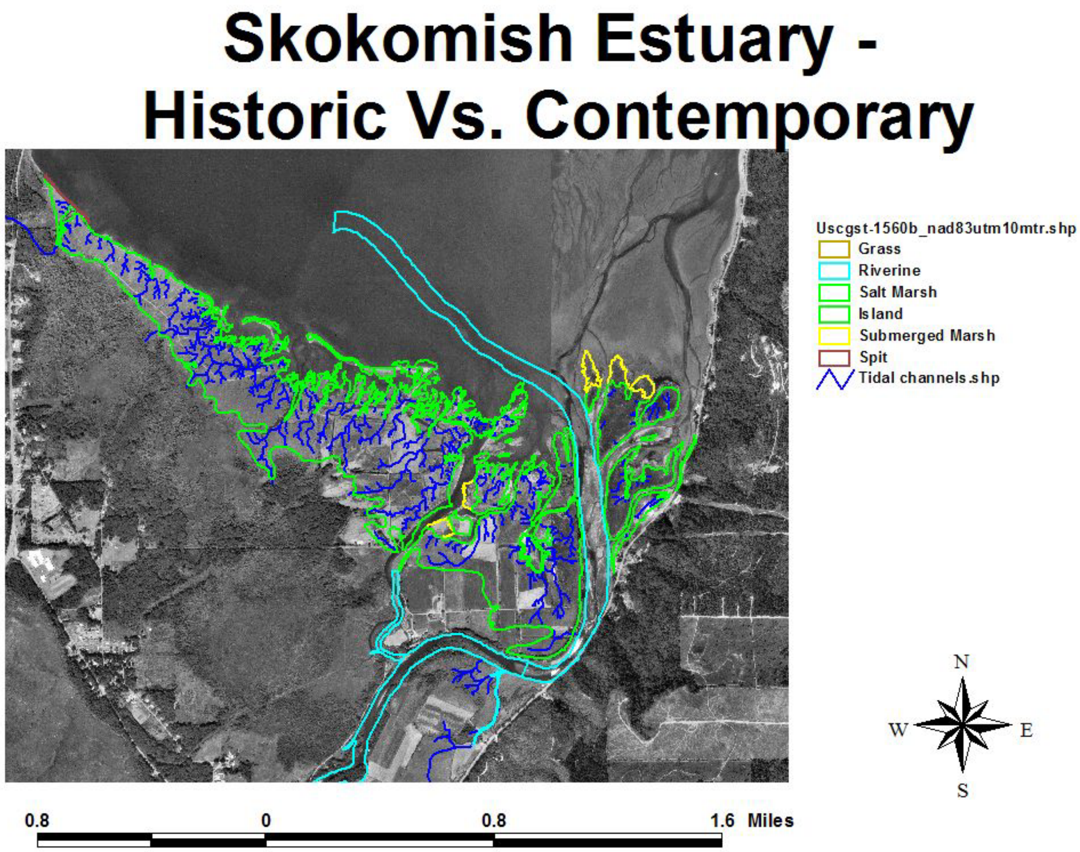

Figure 95. Skokomish Estuary, Historic vs. Contemporary. Graphic provided by Richard Brocksmith, HCCC.

The face of the Skokomish Delta has steepened over time since sediment from the Skokomish River is detained in the lower river channel (Jay and Simenstad 1994). By 1884 some diking had begun along the east side of the Skokomish Delta which eliminated approximately 6 acres of salt marsh habitat. The bulkheads and fill should be removed to restore salt marsh habitat. Hunter Farm Slough needs revegetation and complexity. In 1942 the dike to the north of Nalley Slough was constructed with tide gates and eliminated tidal inundation to the area. Approximately 145 acres of salt marsh habitat was converted to agriculture. Today, there is a natural breach in this dike and the area is no longer utilized for agriculture. Half of the tidal exchange now goes down Nalley Slough so fish have access the rest of the estuary. The dikes along the east side of the island should be removed to allow overflow. The dikes along the south and west side of the island should also be removed. In addition the interior levees and tidegates should be removed. If the levee material is native, it could be pushed back into the borrow ditches, which should be filled wherever possible and when not part of tidal channel development. Historically Skobob Creek entered the mainstem Skokomish upstream of the Nalley Slough convergence, but now enters directly into the slough. All infrastructure, such as access roads, should be removed. An access road utilized by tribal members for shellfish harvest and recreation that extends into salt marsh and the intertidal zone should be relocated to the west to allow inundation of the historic estuary. It appears that some channels have been joined to minimize road access road crossings. Most of the larger channels have properly sized culverts and the road is overtopped during extreme high tides. The access road to the towers should be moved. If maintenance of the towers becomes difficult, the towers should be routed around SR101 and SR106 (TAG 2003).

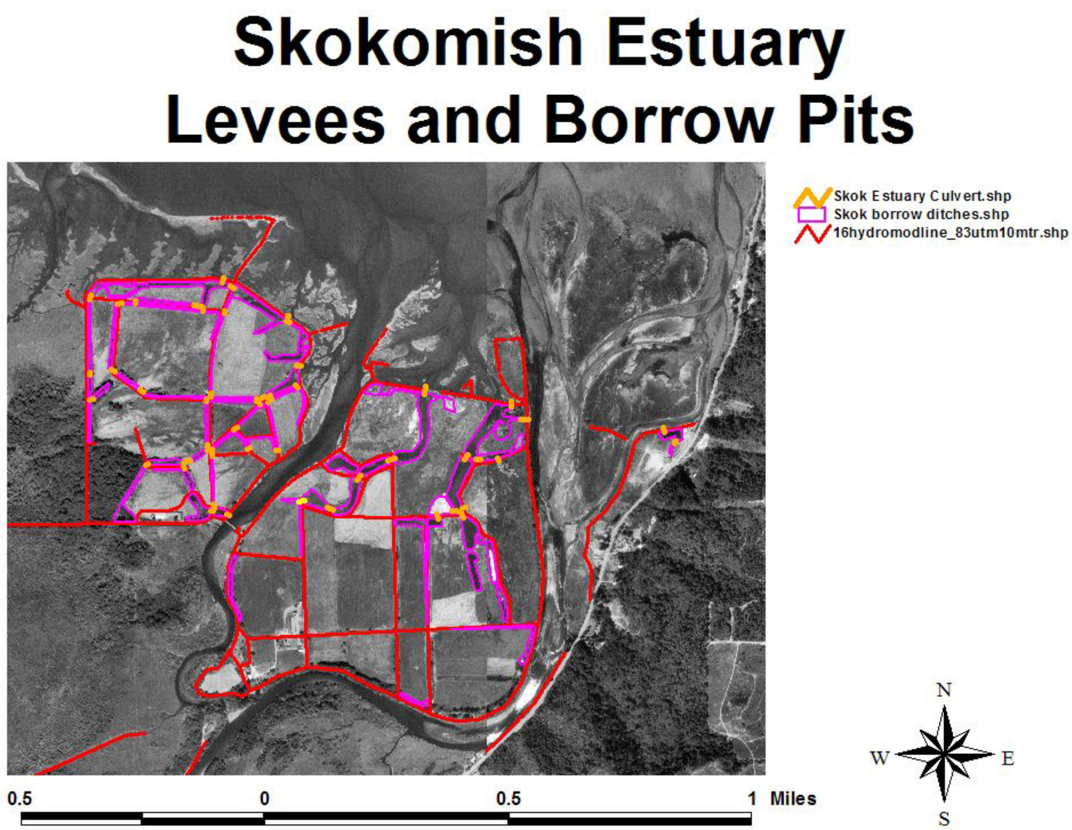

Figure 96. Skokomish Estuary Levees and Borrow Pits, 2003. Graphic provided by Richard Brocksmith, HCCC.

Riparian Loss

SR101 armoring at Little Lilliwaup estuary has eliminated the riparian zone. Numerous sections of SR 101 in this segment of Hood Canal are adjacent to the shoreline and are mostly devoid of native riparian vegetation. In many cases, exotic vegetation has invaded these sites and should be replaced with native species. Riparian vegetation is missing to the north of Miller Creek and between Miller Creek and Clark Creek due to housing development (TAG 2003).

Data Needs

- Investigate septic systems to the south of Hill Creek where seepage and ulva are present
- Investigate the use of herbicides/pesticides along a section of cleaned beach between Hill Creek and TPU power plant
- Investigate, and eventually implement, solutions to discharge from TPU power plant to restore natural shoreline processes
- Determine if the change in sediment recruitment from alongshore/backshore to fluvial origin is adequate to support functions provided by drift cell processes.

Action Recommendations

- Replace undersized culvert at Little Lilliwaup/SR101 with a bridge
- Remove concrete bulkhead and fill on point southeast of Little Lilliwaup Creek to restore nearshore process and migration corridor
- Remove the boathouse southeast of Little Lilliwaup Creek to restore sediment transport and migration corridor
- Remove bulkhead, fill, structures and groins at Lilliwaup Point to restore nearshore processes and juvenile migration corridor
- Remove parking lot fill at Sund Creek to reestablish salt marsh habitat
- Relocate dive shop and parking lot away from shoreline at Sund Creek
- Remove bulkheads, fill and houses north of Miller Creek to restore migration corridor and sediment transport
- Remove riprap and fill north of community center at Miller Creek to reestablish salt marsh habitat
- Remove bulkheads, fill and houses south of Miller Creek to restore migration corridor and sediment transport
- Reduce width of marina pier at Clark Creek
- Replace undersized culvert at Clark Creek
- Remove bulkhead, fill and structures, including creosoted pilings between Clark Creek and Hoodsport
- Remove creosoted pilings north of Hoodsport
- Relocate part of Hoodsport Hatchery to reestablish shallow water migration corridor
- Acquire right bank of mouth of Finch Creek and restore historic estuary
- Remove unused dock, floats, fill and creosoted pilings and relocate buildings at Port of Hoodsport
- Remove bulkhead, fill and three houses to south of Port of Hoodsport
- Remove fill, houses and zigzag intertidal fencing to south of Hoodsport
- Remove structure on pilings to the south of Hoodsport
- Remove bulkhead, fill, dock and structure to the south of Hoodsport

- Remove zigzag bulkhead and adjacent bulkhead, fill and houses to reestablish shallow water migration
- Replace undersized culvert at Hill Creek to reestablish estuary function
- Remove bulkhead, fill and structures to the south of Hill Creek
- Determine beach clean-up methods between Hill Creek and TPU power plant
- Remove fill to historic shoreline midway through parking lot at Cushman boat launch and revegetated with native species
- Restore natural shoreline processes at outlet from TPU power plant
- Daylight lower Minerva Creek and restore estuary
- Remove fill and restore slat marsh and tidal channels at Potlatch State Park
- Reconstruct hatchery trapping facility to allow better estuary function and tidal channel connectivity at Enetai
- Remove bulkheads and fill and restore 6 acres of salt marsh along the east side of the Skokomish Delta
- Remove Nalley Island dikes/levees, roads, borrow ditches and tide gates
- Remove left bank dikes/levees, roads, borrow ditches and tide gates within Skokomish Delta
- Relocate access road to shellfish beds that extends into intertidal zone at the Skokomish Delta
- Remove TPU maintenance/access roads within the delta
- Relocate TPU transmission towers to follow SR101 and SR106
- Pull Pilings from within the delta of old Potlatch Lagoon to restore intertidal wetland

HOOD CANAL LIMITING FACTORS ANALYSIS NEARSHORE STRESSORS – EFFECTS TABLE

Causal Factors/ Stressors	**Physical Processes Altered**	**Physical/Chemical Effects**	**Habitat Effects**	**Juvenile Salmon Effects**
Shoreline Armoring (riprap, bulkheads)	a. erosion/sediment transport (backshore, intertidal and alongshore)	a. altered beach sediment size/type b. decreased sediment abundance c. increased wave energy d. water quality declines from flow alteration, accumulation of drift material (including macroalgae blooms)	a. altered plant/animal assemblages (loss of eelgrass/copepods) b. beach scouring and/or lowering c. loss of shallow nearshore d. loss of connectivity e. altered shoreline hydrodynamics/drift (groins, etc.)	a. reduced prey b. increased predation c. altered migration
Overwater Structures (stairs, docks, marinas)	a. erosion/sediment transport	a. altered beach sediment size/type b. decreased sediment abundance c. light limitation/alteration d. water quality declines from flow alteration, accumulation of drift material (including macroalgae blooms)	a. altered plant/animal assemblages b. altered access to shallow nearshore corridor	a. reduced prey b. increased predation c. altered migration
Ramps	a. erosion/sediment transport	a. altered beach sediment type/size b. altered sediment distribution	a. altered plant/animal assemblages	a. reduced prey
Stormwater Wastewater	a. nutrient input b. freshwater input	a. low dissolved oxygen b. contaminant loading c. nutrient loading d. physical scouring from increased runoff e. increased shoreline erosion from poor stormwater conveyance/maintenance f. alteration of beach hydrodynamics	a. altered plant/animal assemblages (including macroalgae blooms) b. lost habitat due to eelgrass declines from smothering, anoxia, shading, etc. c. forcing of habitat shifts due to blooms (slowing of water, accumulation of nutrients, etc)	a. increased injury risk (lesions, tumors) b. reduced prey c. reduced habitat
Landfill (below the high high water line)	a. tidal exchange b. erosion/sediment transport	a. delta and lagoon loss b. altered beach sediment size/type c. decreased sediment abundance d. increased wave energy	a. altered plant/animal assemblages b. loss of shallow nearshore corridor c. loss of riparian d. beach scouring and/or lowering e. loss of connectivity	a. reduced prey b. osmoregulation (due to delta/lagoon loss) c. increased predation
Riparian Loss	a. nutrient input b. erosion/sediment transport c. large wood function in spit formation	a. increased temperature b. organic input (food web)	a. shade b. erosion c. lwd function	a. reduced prey b. increased predation

PRIORITIZED NEARSHORE ACTION RECOMMENDATIONS

Numerous nearshore action recommendations have been suggested throughout this document. These actions are from a fish perspective as well as hydrologic and biotic estuary/nearshore processes and functions. The TAG accepted the task of prioritizing action recommendations for the nearshore. To do so, they developed criteria to guide the assignment of values to certain parameters. The parameters include proximity to priority watersheds, special scale, temporal scale, and ecological scale. Other criteria were considered, such as the "string of pearls" concept that describes the connectivity of various nearshore habitats (such as proximity of successive salt marshes and their connectivity with contiguous patches of eelgrass) and proximity to other projects, but the TAG felt that the science is not mature enough to include them as criteria at this point in time. The following criteria were used to rank the potential projects:

Proximity to priority watersheds, maximum 5 points
The proximity to priority watersheds, as determined by the Hood Canal Coordinating Council strategy for salmon habitat recovery (Watson 2001), was evaluated as follows:

- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 1 estuary, the action received the maximum of 5 points.
- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 2 estuary, the action received 4 points.
- If the nearshore project action was within 0.0 to 1.o miles from a Tier 3 estuary, the action received 3 points.
- The value was reduced by one point if the action was between 1.0 and 7.0 miles from a Tier 1, 2, or 3 estuary.
- The value was reduced by two points if the action was greater than 7.0 miles from a Tier 1, 2, or 3 estuary.

Spatial Scale, maximum 5 points
The size of the benefit was evaluated as follows:

- The action received the maximum of 5 points if the project protected and/or restored greater than 10 acres of habitat.
- The action received 4 points if the action protected and/or restored 5 to 10 acres of habitat.
- The action received 3 points if the action protected and/or restored 2 to 5 acres of habitat.
- The action received 2 points if the project protected and/or restored ½ to 2 acres of habitat.
- The action received one point if the project protected and/or restored less than ½ acre of habitat.

Ecological Scale, maximum 5 points
Ecological scale was designed to evaluate impacts to nearshore processes. If the action addressed multiple processes, species and life histories, it received a higher value. For example, if an action recommendation involved estuary restoration that would affect both

nearshore and riverine processes, such as dike removal in the lower floodplain, it received a higher score than one that involved a single process, such as the removal of individual creosoted pilings, which systematically received one point.

Temporal Scale, maximum 3 points
Time scale was designed to evaluate the benefit over time. If the action recommendation restored a nearshore process, which is long term by nature, it received a higher score than a project that is more short term and requires a lot of maintenance

General, Basin-wide Recommendations
In addition to the site specific recommendations, there are some general basin-wide recommendations that should be considered when determining nearshore restoration actions to pursue or when making policy and/or regulatory decisions. These include:

- Protection/restoration of sediment sources/naturally eroding bluffs
- Protection/restoration of estuaries
- Protection/restoration of riparian function
- Removal of intertidal fill
- Proper treatment of stormwater and wastewater
- Protection/restoration of salt marsh habitat
- Removal of unused creosoted pilings
- Revegetation of shoreline along SR101
- Consolidation of docks and rail launches
- Soft bank technology

Table 18. Prioritized Nearshore Action Recommendations

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Dosewallips	Remove dikes in vicinity of mainstem Dosewallips River and estuary	103640	5	5	5	3	18
Hamma Hamma	Remove all levees/dikes and armoring, particularly mainstem dike, the dike along the north side of the estuary, and other minor dikes to restore historic mainstem channel, tidal channels and estuary function	102046 101650 101652	5	5	5	3	18
Skokomish	Remove Nalley Island dikes/ levees, roads, borrow ditches and tide gates	153518	5	5	5	3	18
Skokomish	Remove left bank dikes/ levees, roads, borrow ditches and tide gates	153442	5	5	5	3	18
Dosewallips	Remove dike between Wolcott Slough and the Dose mainstem on WSP ownership	103652	5	4	5	3	17
Duckabush	Elevate SR101 across estuarine delta to restore tidal connectivity, reestablishment of native vegetation,	102944	5	5	5	2	17
Hamma Hamma	Replace SR101 causeway/bridge with an elevated structure across the entire delta	102046 101650 101652	5	5	5	2	17
Jorsted Creek	Relocate SR101 to the west, acquire estuary and restore Jorsted Creek to equilibrium location	101530	5	5	4	3	17
Eagle Creek	Relocate SR101 to the west and remove fill to reestablish salt marsh and tidal connection to the lagoon	101254	5	5	4	3	17
Cabin Point/ Lilliwaup	Restore sediment supply from feeder bluff	101202 101122	5	5	4	3	17
Neelim Point	Restore backshore sediment supply to restore beach berm protecting Neelim salt marsh	100552 100532	5	5	4	3	17

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Dosewallips	Wolcott Slough: replace SR 101 culvert at northern part of Wolcott Slough with a bridge, provide tidal channel connection with bridgeway over access road to east of SR101, replace undersized culvert with bridge over slough to the south, remove dikes, connect upper tidal channel west of SR 101 with larger lagoon with a bridge on the access road	103720	5	4	5	2	16
Duckabush	Reconnect northern distributary channel with the Duckabush River	102848	4	4	5	3	16
Jorsted Creek	Restore sediment supply from feeder bluff	101450	5	4	4	3	16
Lilliwaup	Extend SR101 bridge span and remove shoulders/fill	101100	5	5	4	2	16
Skokomish	Remove bulkheads and fill and restore 6 acres of salt marsh along the east side of the delta	152522	4	4	5	3	16
Skokomish	Remove TPU maintenance/access roads with the delta	153442	5	3	5	3	16
Skokomish	Relocate TPU transmission towers to follow SR 106	153442	5	3	5	3	16
Dosewallips	Sylopash slough tidal prism and riparian restoration	103704	4	4	5	2	15
Hamma Hamma	Remove bulkhead and fill that forms an unused part of a parking lot to the north of shellfish facility to restore salt marsh habitat	101630	3	4	5	3	15
Skokomish	Relocate access road to shellfish beds that extends into intertidal zone at the Skokomish Delta	153442	4	4	5	2	15
Duckabush	Remove dike along north side of estuary along Robinson Road	102852	3	3	5	3	14
Duckabush	Reconfigure intersection of SR101 and Duckabush River Road to reconnect Pierce Creek Slough	102849	3	4	5	2	14
Fulton Creek	Lengthen bridge span over Fulton Creek to restore historic salt marsh habitat	102616	4	4	4	2	14
Lilliwaup	Remove trout pond diking, set back structures and roads and expand access road bridge		3	4	4	3	14
Dosewallips	Remove barge at mouth of Walker Creek	103632	1	4	5	3	13

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Fulton Creek	Remove armoring and fill along north side of Fulton Creek estuary to restore salt marsh/island habitat	102616	2	4	4	3	13
Fulton Creek	Remove armor forming old boat launch and basin west of SR101	102616	2	4	4	3	13
Ayock Point	Preserve and expand remnant salt marsh to include remnant lagoon and reestablish tidal connection at northern end of spit to the south of Ayock Creek	101420	3	3	4	3	13
Miller Creek	Remove bulkheads, fill and houses north of Miller Creek to restore migration corridor and sediment transport	100736	3	3	4	3	13
Hill Creek/ TPU Powerplant	Determine beach clean-up methods between Hill Creek and TPU powerplant	100442	3	4	4	2	13
TPU Powerplant	Remove fill to historic shoreline midway through parking lot at Cushman boat launch and revegetate with native species	100434	3	3	4	3	13
TPU Powerplant	Restore natural shoreline processes at outlet from TPU powerplant	100434	3	3	4	3	13
Minerva	Daylight lower Minerva Creek and restore estuary function	100428	3	3	4	3	13
Potlatch	Remove fill and restore historic salt marsh and tidal channels at Potlatch State Park	100418	3	3	4	3	13
Black Point Lagoon	Reestablish historic tidal connection	103242	3	3	4	2	12
Duckabush	Improve connection with the small creek flowing through undersized culvert into the nw corner of Duckabush estuary	102852	2	3	5	2	12
Duckabush	Restore Pierce Creek and tidal connectivity by bridging Shorewood Road and restoring riparian function		2	3	5	2	12
McDaniel Cove	Remove fill at head of cove to restore salt marsh habitat	102708	2	3	4	3	12
Fulton Creek/ Triton Cove	Remove parking lot on WDFW property along the south shore of an independent tributary and reestablish riparian vegetation	102602	2	3	4	3	12
Beacon Point	Relocate houses and associated bulkheads that extend into intertidal zone to restore migration corridor and sediment transport	102344	2	3	4	3	12

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Wacketickeh	Remove fill and relocate structures along north side of Wacketickeh estuary	102110	2	3	4	3	12
Jorsted Creek	Remove creosote pilings to north of Jorsted Creek	101538	3	2	4	3	12
Ayock Point	Acquire and remove bulkheads along south part of south side of Ayock Point	101424	2	3	4	3	12
Ayock Point	Acquire and remove 4 houses north of Ayock Creek to restore channel to former location	101424	2	3	4	3	12
Ayock Point/ Eagle Creek	Purchase and remove bulkhead/fill and residences between Ayock and Eagle Creek to reestablish shoreline processes, backshore sediment recruitment and migration corridor	101352	2	3	4	3	12
Little Lilliwaup	Remove bulkhead, fill, structures and groins at Lilliwaup Point to restore nearshore processes and juvenile migration corridor	100908	2	3	4	3	12
Hoodsport	Remove unused dock, floats, fill and creosoted pilings and relocate buildings at Port of Hoodsport	100616	2	3	4	3	12
Enetai	Reconstruct hatchery trapping facility to allow better estuary function and tidal channel connectivity at Enetai	100358	2	4	4	2	12
Seal Rock	Remove paved area/boathouse and pilings associated with housing development north of Seal Rock campground to reestablish sediment drift and migration corridor	104236	1	3	4	3	11
Seal Rock/ Dosewallips	Remove derelict structure, fill and riprap associated with aquaculture between Seal Rock and Dose	104156	1	3	4	3	11
Dosewallips	Examine seal exclusion fence and/or look at alternatives	103652	1	2	5	3	11
Pleasant Harbor	Remove structures inside of accretion spit and restore salt marsh and riparian vegetation	103506	1	3	4	3	11
McDaniel Cove	Remove jetty fill in McDaniel Cove	102708	1	3	4	3	11
Triton Head	Remove tide gate and culvert and return a swimming pond along south side of Triton Head to salt marsh to limit impacts to fish	102400	2	2	4	3	11

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Beacon Point	Relocate community picnic area at Beacon Point to restore salt marsh habitat	102344	1	3	4	3	11
Mike's Beach	Relocate cabins and associated bulkhead to reestablish juvenile migration corridor and sediment transport	102158	1	3	4	3	11
Hamma Hamma	Remove creosoted pilings	102052	1	2	5	3	11
Hamma Hamma	Remove pilings from existing spit	101646	1	2	5	3	11
Hamma Hamma	Remove exotic vegetation in the vicinity of shellfish facility and replant with native conifers and shrubs	101624	2	2	5	2	11
Jorsted Creek	Remove armoring, fill and log skid apparatus to north of Jorsted Creek	101538	1	3	4	3	11
Ayock Point	Acquire and remove bulkhead and house at north end of north side of Ayock Point	101442	1	3	4	3	11
Ayock Point/ Eagle Creek	Purchase and relocate or remove bulkhead/fill and house between Ayock and Eagle Creek	101402	1	3	4	3	11
Ayock Point/ Eagle Creek	Remove abandoned, triangular bulkhead and fill to north of Eagle Creek	101326	1	3	4	3	11
Eagle Creek/ Carroll/ Cabin Point	Remove bulkhead and fill between Eagle Creek and Carroll/Cabin Pt to preserve and enhance salt marsh	101232	1	3	4	3	11
Lilliwaup	Remove fill and development seaward of southern bridge abutment of SR101 to reestablish salt marsh habitat	100928	1	3	4	3	11
Lilliwaup	Daylight creek to falls on right bank of Lilliwaup estuary west of SR101 bridge	100932	1	3	4	3	11
Little Lilliwaup	Remove concrete bulkhead and fill on point southeast of Little Lilliwaup Creek to restore nearshore process and migration corridor	100914	1	3	4	3	11
Little Lilliwaup	Remove boathouse southeast of Little Lilliwaup Creek to restore sediment drift and migration corridor	100914	1	3	4	3	11
Sund Creek	Remove parking lot fill to reestablish salt marsh at Sund Creek	100810	1	3	4	3	11

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Sund Creek	Relocate dive shop and parking lot away from shoreline at Sund Creek	100810	1	3	4	3	11
Miller Creek	Remove riprap and fill north of community center to reestablish salt marsh habitat	100736	1	3	4	3	11
Miller Creek	Remove bulkheads, fill and houses south of Miller Creek to restore migration corridor and sediment transport	100736	1	3	4	3	11
Clark Creek/ Hoodsport	Remove bulkhead, fill and structures, including creosoted pilings between Clark Creek and Hoodsport	100640	1	3	4	3	11
Hoodsport	Relocate part of Hoodsport Hatchery to reestablish shallow water migration corridor	100628	1	3	4	3	11
Finch Creek	Acquire right bank of mouth of Finch Creek and restore historic estuary	100632	1	3	4	3	11
Hoodsport	Remove bulkhead, fill and three houses to south of the Port of Hoodsport	100612a	1	3	4	3	11
Hoodsport	Remove fill, houses, and zigzag intertidal fencing to south of Hoodsport	100612	1	3	4	3	11
Hoodsport	Remove structure on pilings to the south of Hoodsport	100612	1	3	4	3	11
Hoodsport	Remove bulkhead, fill, dock and structure to south of Hoodsport	100604	1	3	4	3	11
Hoodsport	Remove zigzag bulkhead and adjacent bulkhead, fill and houses to reestablish shallow water migration	100558	1	3	4	3	11
Hill Creek	Replace undersized culvert at Hill Creek to reestablish estuary function	100554	2	3	4	2	11
Hill Creek	Remove bulkhead, fill and structures to south of Hill Creek	100554	1	3	4	3	11
Skokomish	Pull pilings from within the delta of old Potlatch Lagoon to restore intertidal wetland	153204	1	3	4	3	11
Seal Rock	Investigate and remove if necessary, riprap at Seal Rock Campground parking lot	104202	1	2	4	3	10
Dosewallips/ Quatsap Point	Remove pilings to the south of Walker Creek	103544	1	2	4	3	10
Pleasant Harbor	Remove fill associated with parking lot on WDFW property at end of Pleasant Harbor	103446	1	2	4	3	10

Location	Action Recommendation	Ecology Photo Reference	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Triton Cove	Native plant revegetation on state park access	102554	2	2	4	2	10
Triton Cove	Remove abandoned creosote pilings	102458	1	2	4	3	10
Beacon Point	Remove creosote pilings	102344	1	2	4	3	10
Mike's Beach	Redesign dock at Mike's Beach to eliminate fill and reestablish shallow water migration corridor	102202	1	3	4	2	10
Mike's Beach	Extend SR101 span across the campground creek	102154	1	3	4	2	10
Wacketickeh	Extend bridge across the Wacketickeh to reestablish lost tidal channel	102110	1	3	4	2	10
Little Lilliwaup	Replace undersized culvert at SR101 with bridge	100912	1	3	4	2	10
Clark Creek	Replace undersized culvert at Clark Creek	100714	1	3	4	2	10
Clark Creek/ Hoodsport	Remove creosoted piling north of Hoodsport	100636	1	2	4	3	10
Seal Rock	Investigate drainage at Seal Rock Campground parking lot and ameliorate if necessary	104202	1	2	4	2	9
Triton Cove	Stormwater and bilgewater remediation on state park access	102554	1	2	4	2	9
Triton Cove	Combine multiple docks into one on state park access	102554	1	2	4	2	9
Clark	Reduce width of marina pier at Clark Creek	100714	1	1	4	2	8

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